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Conference on Inland Navigation
(1895: Birmingham, England)
Report of the proceedings of
the Conference on Inland Navigation,
Birmingham, February 12th, 1895

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THE FEDERATED INSTITUTION OF MINING ENGINEERS.

REPORT OF THE PROCEEDINGS

OF THE

CONFERENCE

ON

INLAND NAVIGATION,

BIRMINGHAM,

FEBRUARY 12TH, 1895.

WITH MAP OF ENGLISH CANALS.

EDITED BY M. WALTON BROWN.

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTION.

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CONTENTS.

PAGE.

Opening Address by the President (Mr. W. N. Atkinson) 1

"The Relative Progress of Railways and Waterways, and the Methods Suggested by Its Consideration for Promoting the Arrested Development of the Latter." By Mr. Urquhart A. Forbes 3

"The Comparative Conditions and Costs of Transport by Railway and Canal." By Mr. J. Stephen Jeans 16

"Canals." By Mr. Lionel B. Wells, M. Inst. C.E. 27

"Canals." By Mr. J. A. Saner, Assoc. M. Inst. C.E.... 51

Discussion—Mr. W. H. Hunter 65
Mr. Urquhart A. Forbes 67
Mr. J. A. Saner 68
Mr. Emerson Bainbridge 68
Mr. M. H. Mills 69
Mr. Jeremiah Head... 70
Mr. T. Forster Brown 71
Mr. G. E. Coke 72
Mr. H. C. Peake 73
Mr. W. Spencer 73
Mr. S. Lloyd... 73
Mr. Collier 74
Lord Francis Hervey 74
Mr. John T. Brunner, M.P. 75
Mr. Lionel B. Wells 75
Sir E. Leader Williams 80
Mr. J. A. Saner 81
The President 82
Mr. Emerson Bainbridge 82
Mr. G. J. Binns 82

"The Severn Navigation, with Particular Reference to Recent Improvements." By Mr. E. D. Marten, M. Inst. C.E. 83

"Inland Navigation, with Special Reference to the Birmingham District." By Mr. L. F. Vernon-Harcourt, M. Inst. C.E.... 95

"Canals and Their Improvements, more Particularly Applying to the London and Birmingham Trade." By Mr. W. Salt 110

1

PAGE.
"Birmingham and its Canal-connexion with the Seaports." By Mr. W. H. Wheeler, M. Inst. C. E. 116

Discussion—Mr. J. A. Saner 120
Mr. Geo. W. Keeling 121
Mr. Lyonel Clark 122
Mr. Samuel Lloyd 126
Mr. Beriah Shepherd 126
A Member 128
Mr. E. D. Marten 128
Mr. L. F. Vernon-Harcourt 130
Mr. J. Head 132
Mr. Emerson Bainbridge 132

ILLUSTRATIONS.

Map of Canals and Navigable Rivers of England and Wales. By Mr. Lionel B. Wells, M. Inst. C.E. ... ... *Frontispiece.*

Diagram showing in Tons per Kilometre the Quantity of Goods and Minerals moved from 1847 to 1891 by Waterways and Railways in France. By Mr. Lionel B. Wells, M. Inst. C.E. 47

Sections of Canals and Canal-locks. By Mr. J. A. Saner, Assoc. M. Inst. C.E. 53

Westgate Bridge, Gloucester, showing the Comparative Outlines of the three worst Bridges on the River Seine. By Mr. E. D. Marten, M. Inst. C.E. 90

Sections of Waterways from Birmingham to Seaports. By Mr. L. F. Vernon-Harcourt, M.A., M. Inst. C.E. 108

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

CONFERENCE ON INLAND NAVIGATION.

BIRMINGHAM, FEBRUARY 12TH, 1895.

MR. W. N. ATKINSON, PRESIDENT, IN THE CHAIR.

The PRESIDENT said that the members were about to consider several papers on canals written by gentlemen specially competent to deal with the subject. Probably some of the members might not have much technical knowledge concerning canals, but it did not require such knowledge to be able to appreciate the great importance of all means of transport to an industry such as the mining industry of this country, which produced 200,000,000 tons of minerals annually—cheap and efficient means of transport were to it of vital importance. The question of cheap transport assumed additional importance in times of depressed trade, and the South Staffordshire coal-field was served by canals to a greater extent than most others, so that both the time and place of this meeting seemed specially appropriate for the consideration of these papers. The inland navigations of this country appeared from various causes to have been greatly neglected since the advent of railways, and in this respect we were said to lag behind many European nations and the United States of America. Various reasons were assigned for the present inefficiency of inland waterways, one of which was the effect of railway control over a considerable portion of them, and in so far as it eliminated competition this seemed to be a natural consequence of such control. Another cause was the want of uniformity of gauge in the construction of canals, which must be fatal to the efficiency of the system as a whole. The adoption of some form of mechanical haulage also seemed essential to the complete efficiency of transport by canals. The only effectual remedy for the present state of affairs would appear to be the creation of some controlling authority over all the canals of the country. These and many other aspects of the question would be treated by the writers of the papers, and he thought that the reading of those papers, and the discussion thereon would afford valuable information on the important subject of the inland navigation of Great Britain.

The following paper by Mr. Urquhart A. Forbes on "The Relative Progress of Railways and Waterways," etc., was taken as read:—

THE RELATIVE PROGRESS OF RAILWAYS AND WATERWAYS, AND THE METHODS SUGGESTED BY ITS CONSIDERATION FOR PROMOTING THE ARRESTED DEVELOPMENT OF THE LATTER.

BY URQUHART A. FORBES.

It is somewhat curious, and is certainly to be regretted, that in an age so fruitful in historic research as the present, the history of the development of our transport system—of which the arrested development of our waterways would form one of the most interesting chapters—has yet to be written. The practical importance of the subject must be generally admitted. Its records date back to the time when Britain was for four centuries a Roman province. The inventions connected with it have, by abridging distance, contributed more, as Lord Macaulay pointed out, towards the advancement of civilization than any others save those of the alphabet and the printing-press. And, lastly, it has been the chief means of proving to the world that distribution is one of the most essential branches of production, and not a separate and co-equal work with it.

This important fact, which is very clearly demonstrated by the Duke of Argyll in his valuable work on *The Unseen Foundations of Society*,* and of the practical recognition of which the share taken by manufacturers and traders in the promotion of the Manchester ship-canal affords a striking illustration, appears so self-evident that its statement may seem to be a mere truism. It is now apparently so obvious that the most abundant harvests and the largest stores of manufactured goods are valueless unless they can be rendered accessible to those who need them, that it is hard to realize that this fact was only very partially grasped by the earlier political economists, and has only been brought home to the general public through the enhanced powers of distribution which the development of transport has conferred on the trader, and without which he would be utterly unable to meet the demands for products of all kinds from our vast and ever-increasing population. History, however, shows that,

* Page 457.

though the development of transport by breaking down the barriers of time and space appears to be gradually producing, as it certainly has done among nations, more harmonious relations between the producer, the distributor, and the consumer, these relations have hitherto always been hostile, if not belligerent, and that the efforts of the State to adjust the balance between their conflicting interests have generally resulted in the arrangement of a sort of "three-cornered duel."

In Edward III.'s reign, for instance, we find the State, with the best intentions, endeavouring to suppress the distributor in order to protect the supposed interests of the producer and the consumer, by enacting that the publicans of Yarmouth were to make no more wholesale bargains with the fishermen, while the latter were to be assured of the full prices obtainable in an open market. Though, however, everything was to be regulated by a supposed spirit of equity embodied in a law, the plan broke down completely in four years. The fishermen could not leave their boats and nets to attend an open market, while the "hated middlemen," who were found to have discharged a function which the first producers were unable to discharge for themselves, could no longer count on the profits which alone could compensate them for dealing in a very perishable article. They had, in fact, produced one of the most valuable products, namely, distribution, and the king and Parliament, with a courage not to be expected from a government of the present day, acknowledged their mistake and repealed the benevolent law.* The growth of trade gradually forced the State to recognize that the trader in his capacity of distributor was not only indispensable to the original producer, but was also worth encouraging on his own account, and it then began to confer on him special privileges, such as those contained in the charters granted to the trading-guilds and companies of the Middle Ages. When the necessity for increased facilities of transport called into being a new branch of distribution which, like the first—that of wholesale and retail trade—and like the majority of our most valuable institutions, originated in private enterprise, the State pursued the same policy. It had now, however, to deal with new and more complex conditions, owing, on the one hand, to the rights of the owners of the land proposed to be appropriated for purposes of transit, and, on the other, to the extensive powers which it was necessary to confer on those who undertook to meet the needs of the public in this respect. The new distributors, the constructors of our highways by road, by water, and by rail, instead of being treated as pernicious and unnecessary—as were the original distributors, the traders, in Edward III.'s reign—therefore obtained from the State important privileges which have been a constant source of friction between them and the consumer, the producer, and their co-distributors, the traders. And in addition to this, the competition for popular support and State patronage has naturally generated a spirit of hostility between railway companies and canal companies, which might not improbably have been also equally strongly developed between both of these and turnpike trustees, had not the abolition of turnpikes prevented highways by road from being utilized for the purposes of a remunerative "carrying trade" by privileged corporations.

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* *The Unseen Foundations of Society*, pages 87 and 529.

The State doubtless never originally intended that the privileges, which it thus granted to private enterprise, and without which our transport system could never have been developed, should be permanent. As regards highways by road, the abolition of turnpike trusts is a proof of this. With respect to railways, we have equally strong evidence in the provisions, still unrepealed though never enforced, of the Act of 7 and 8, Vict., c. 85, based on the report of a committee of 1844, of which Mr. Gladstone was chairman; first, for the revision of the scale of tolls of railways if after twenty-one years from the passing of the Act for the construction of any future railway the profits should exceed 10 per cent; and, secondly, for the purchase by the Treasury at any time after expiration of the said twenty-one years of any such railway in the name and on behalf of Her Majesty.* That there is, so far as the writer is aware, no such provision in any Act relating to canals may not improbably be explained by the fact that they had not assumed sufficient importance at the time when they were superseded by railways to induce the Legislature to consider the advisabilty of either curtailing the powers of the companies or of purchasing their undertakings. As, however, it is always liable to be influenced by some temporarily dominant interest, the State can never be expected to be a thoroughly impartial, and still less an infallible tribunal. Under the fascination of railway enterprise, it not only speedily abandoned the good intentions which it had announced in the statute above referred to, but also allowed the railway companies to obtain control over more than half of the inland navigations of England and Wales, and thus reduced canal companies to what physiologists term a "state of suspended animation."

The action of the railway companies in this respect was undoubtedly in many cases of questionable legality, and it is some satisfaction to reflect that, though by their adroit manipulation of the waterways over which they have obtained command, they have succeeded, as Mr. Conder forcibly expressed it in his evidence before the Select Committee of 1883 on Canals, "in strangling the whole of the inland water-traffic," their selfish policy has considerably interrupted their own lucrative and legitimate trade.* It would, however, be as unfair as it seems unwise to lay the whole blame for the present condition of inland navigation, for which the canal companies themselves are largely responsible, upon the railway companies' shoulders. It must always be remembered, in considering the competition between the two, that the canal companies had the advantage of being the first in the field. As early as 1792, the premiums of single shares in companies had reached such figures as £155 (Leicester), £350 (Grand Trunk and Coventry), and £1,170 (Birmingham).†

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* Sections 1 and 2.

In 1806, we find the *Times* commenting with admiration on the fact that troops were being transported by canal from London to Liverpool *en route* for Ireland in only seven days. By 1830, five years after the opening of the Stockton and Darlington line—the birth-year of the railway system—£14,000,000 had been expended in constructing 4,332 miles of waterways, which furnished twenty-one through routes between London and the manufacturing districts. Never had private enterprise more brilliant prospects, and yet by 1846, though canals, such as the Oxford, the Coventry, and the Trent and Mersey, were producing dividends of 25, 26, and 30 per cent., we find their proprietors actually putting pressure upon railway companies to compell them to purchase their undertakings. The whole nation seems to have been carried away by the railway mania, and to have abandoned the costly and admirably designed system of water-communication with which it had been provided as no longer worthy of consideration. With a few exceptions, such as the Leeds and Liverpool and the Aire and Calder canals, the remunerative nature of which still continues to justify the wisdom of their promoters,‡ capital was everywhere withdrawn from canals to be invested in railways. During the three years, 1845, 1846, and 1847, the railway companies were permitted, if not indeed encouraged, to purchase 948 miles of waterways, a total subsequently increased to 1,717. The mileage of the waterways owned by the 63 independent canal companies is now reduced to 2,486, while their capital, including Government grants to Scottish and Irish canals, is only £30,656,000, more than half of which must be credited to a single undertaking, the Manchester ship-canal. The mileage of the railways has, on the other hand, risen from 6,890 in 1851 to 20,646 in 1893, and the total capital of the railway companies from £248,240,896 to no less than £971,323,353.

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* Appendix 11, page 238. † *Gazette*, August, 1792.

‡ See as to the expenditure and enterprise with regard to these canals, a paper contributed by Mr. Edward Lloyd to the Conference on Canals, 1888, on "Inland Navigation in Great Britain." *Report of the Conference on Canals, etc., Society of Arts*, pages 30 and 31.

It must be admitted that the results of the competition between railways and canals, as shown by the above comparison, are not encouraging to those who, realizing their value, desire to see the latter placed on such a footing as to form a counterpoise to the undue influence of the former. But, uphill though it be, there are good reasons for refusing to abandon the struggle as hopeless. That it is hopeless to attain success by assailing the railways through Parliament seems indeed undeniable. Canal companies lost their "Parliamentary influence," as a matter of course, when the public deserted them fifty years ago; while, leaving out of consideration the large proportion of the nation pecuniarily interested in the prosperity of the railway companies, and the members of both Houses of the Legislature included in the number, fifty members of the Upper and one hundred and thirty, or nearly one-fifth, of the members of the Lower House are officially connected with them. Though the traders have secured a re-adjustment of the railway rates under the Railway and Canal Traffic Act they have derived no appreciable benefit from it; and as the railway companies, by destroying the efficiency of waterways, have secured an excess of traffic, which is already a serious hindrance to their practical utility, no amount of reduction in their charges would enable them better to meet the urgent demands of the traders for increased facilities of transport. And though such a reduction might very well go far to ruin the railway companies, it is manifest that it would in no whit increase the efficiency of the canal companies; while, having regard to the outlay necessary before our canals, the majority of which were constructed on the antique methods of the last century,* could be rendered remunerative, there is no reasonable ground for anticipating that any Government could be induced to sanction their purchase by the State, or that, if bold enough to do so, it could afford to throw them open to the public free of toll.

State aid in either of these forms would seem to be a useless retrogression to the unsound policy, which Edward III.'s Parliament found to be so entirely impracticable when attempted in the interests of the Yarmouth fishermen five centuries ago. On the other hand, the successful completion of the Manchester ship-canal shows what can still be effected by private enterprise when supported by a great and wealthy municipality, and there seems little doubt that it is on energetic and well-directed private enterprize, and on it alone, that those who are striving for the resuscitation of our waterways should rely. It is after all to this source that the success of the railway movement is to be traced. Those who are naturally jealous of the influence over the Legislature which this success has obtained for the railway companies are apt to forget the difficulties with which they originally had to contend, not only through the strenuous opposition of the landed interest and the distrust of the public for the new form of transport, but also through the general ignorance, in which they themselves necessarily shared, which at first prevailed with regard to the true nature and capacity of the railway system. The chief methods by which they have triumphed over this last class of difficulties, and have brought their system to its present perfection appear to be:—(1) By the construction of through routes controlled by single authorities; (2) by the organization of a carrying-trade on these routes; and (3) by the establishment of the railway clearing-house; and as all of these methods seem equally applicable in the case of waterways, it may be useful to consider how far they can be utilized for reviving the development of the latter.

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* "Canal Engineering," by Mr. L. F. Vernon-Harcourt, *Report of the Conference on Canals*, *Society of Arts*, 1888, page 3, *et seq.*

1. As regards through routes, it is interesting in connexion with the present conference to recall the facts that the success of the railway system dates from the opening of the line from Birmingham to London in 1838, and that the bill authorizing its construction was the subject of the greatest parliamentary conflict in the history of railways, and involved an expenditure of £70,000. Within four or five years of its passing, the foundations of all the great trunk-lines were laid, and their successful development affords a good illustration of the truth of Sir Arthur Cotton's contention that it is communication which makes traffic, and not, as is often erroneously stated, traffic which makes communication.* Not only do towns spring up everywhere along the great lines, but those too far removed to benefit by them, find their trade diverted to others which have the advantage of being close to them—as, for instance, in a large tract of the Cotswolds, with which the writer is acquainted, where not a few of the market towns have suffered in this way owing to their

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* *Report of the Select Committee on Canals*, 1883. Appendix 21, page 287. "On a certain line, in its natural state, 1,000 tons a year may be carried on men's heads; if a rough road is made, 10,000 tons may be carried by pack animals; if a good wheel road is opened, 100,000 tons may be moved; if a railway, charging 1d. per ton-mile, 500,000 tons; if a steamboat canal, carrying at 20 ton-miles per 1d., 5,000,000 tons."

distance from the Midland and Great Western railways, which, meeting at Bath and at Cheltenham, completely encircle it. Owing to the fact that they have all acquired control over the whole length of their through routes, the great railway companies have been able to "capture" the traffic of the entire territory that they traverse; but, though there are, as already stated, twenty-one through routes by water in England and Wales, there is not one which has had the advantage of being under one governing body, and all, consequently, bristle with inconveniences calculated to drive away traffic even when it is abundantly to be found within easy reach of them.

Two typical instances may be cited in proof of the contrast between railways and canals in this respect. Three years ago, the Lancashire, Derbyshire, and East Coast Railway Company projected a line from Warrington docks, on the Manchester ship-canal, to Sutton-on-the-Sea, between Grimsby and Boston. This through route between the Atlantic and North Sea coasts is almost parallel in direction to that provided by the Great Western Railway between London and the Bristol Channel, and about the same length, 118 miles. Both lines pass through agricultural, coal-producing, and manufacturing districts containing various populous centres, and both occupy a similar position as to competition with waterways, there being three through routes by water from Liverpool to Hull and three from London to the Severn ports. In the case both of the northern and southern cross-country waterways, each of the through routes begins in a common tidal estuary and, after diverging to traverse its special tract of country, reunites with the other two in another common estuary; and it might at first sight seem that their threefold nature would give them an advantage over the railways in the competition. When we examine the conditions under which traffic is carried on, however, the advantage enjoyed as to through routes by a single competing railway (handicapped though it be by the conveyance of passengers which take precedence of goods), is at once apparent. The first of the northern through routes commences with the Leeds and Liverpool canal and joins the Aire and Calder navigation, reaching the estuary of the Humber after a course of 180 miles. The second—by the Mersey, the Duke of Bridgewater's canal, the Rochdale, Calder and Hebble, and Aire and Calder canals—has a length of over 150 miles; while the third, which is a few miles shorter, runs from the Mersey *via* the Duke of Bridgewater's, Rochdale, Ashton, Huddersfield, Sir John Ramsden's, and Calder and Hebble to the Aire and Calder canals. In addition to the navigation authorities of the

Mersey and the Humber rivers, this through route system of waterways is controlled by eight different companies, amongst whom there is the keenest competition. On the first route, the Leeds and Liverpool canal, the gauge of the locks is 70 feet by 16 feet with a draught of about 4½ feet, while on the Aire and Calder it is 112 feet by 22 feet with a draught of 9 feet. On the last and shortest route, a consignment of goods has to traverse ten distinct waterways, the gauges of locks on which range through various grades from 50 feet by 14 feet by 4·6 feet on Sir John Ramsden's canal to 212 feet by 22 feet by 9·6 feet on the Aire and Calder. The three through routes from the Thames to the Severn are in like manner governed by two conservancy authorities, two town corporations, one railway company, and seven canal companies, and exhibit the same interesting variety as respects the gauges of their locks; and as similar conditions prevail in every through route it is no matter for surprize that the vexatious and injurious delays which they entail should drive the trader to employ the more costly means of transit provided by railways. These defects of our system of inland navigation can only be remedied by placing all the independent links which make up each through route under one authority, and it is cheering to note that a step in this direction was made last year by the Grand Junction Canal Company and by the Grand Canal (Ireland) Company, the former of which purchased the Grand Union, the Leicestershire, and the Northamptonshire Union canals, and the latter the Barrow navigation. When carried on in this way by individual companies this process of consolidation must, however, of necessity be slow, and those who desire to see waterways placed on the footing which they deserve must agree in hoping that it may be accelerated before long by the realizations of such schemes as that for connecting Birmingham with the German Ocean by means of the Trent and the still more important one for uniting it with London described by the late Mr. Marten at the Conference on Canals of 1888.*

2. The gradual development of opinion among railway companies with respect to the carrying-trade is equally worthy of the attention of canal companies. At their first construction, railways were regarded as "land canals," and the Legislature passed Acts authorizing any person to run his trains over lines on payment of the requisite tolls, and empowering owners of adjacent lands to make branch lines having free access to the railways, and lords of manors to erect wharves, and use such portions of the lines as passed through their lands free of charge. The companies

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* *Report of the Conference on Canals, Society of Arts*, page 63.

themselves declared that it was against their wish, and would be against their interest to attempt the carriage of goods and passengers, and that they were desirous of being toll-takers only. It is needless to say that the beginning of their prosperity dates from the time when they overcame their repugnance in this respect, but as late as 1840 private carriers were still found competing with the companies on some lines, such as the Grand Junction and the Great Western.

The witnesses examined on this subject by the Select Committee on Canals were divided in opinion, some, like Mr. Clark, of Wolverhampton, advocating that carrying on canals should be entirely entrusted to private traders, and others, such as Mr. Lloyd, manager of the Warwick canals, and Mr. Bartholomew, engineer of the Aire and Calder navigation, strongly urging the advisability of canal companies acting as carriers. The statement of Sir Frederick Peel, chairman of the Railway Commission, that, owing to carrying on the majority of canals being done by private traders, the commissioners could only deal with complaints as to the conveyance of traffic where they had reference to the tolls for the use of the waterway, seems, however, to give additional weight to the latter view. It appears, moreover, to be largely justified by the evidence as to the relative numbers and commercial importance of the carrying and solely toll-taking canals furnished by the returns made to the Board of Trade in 1890, under section 39 of the Railway and Canal Traffic Act, 1888.*

Of the canals of the United Kingdom, which have a total mileage of 3,813 miles, only eighteen with a total mileage of 1,380 act as carriers, ten of which—six in England, one in Wales, and three in Ireland—are independent, while the remaining eight, which are all in England, are owned by railways. Though the mileage of the seven independent canals in England and Wales is 200 miles less than that of the eight owned by railway companies, the revenue earned as carriers by the former is more than double that owned by the latter, £433,006 as against £199,042, as is also the amount taken in tolls. If the three independent carrying canals in Ireland be added, the revenue of the ten independent canals as carriers will be found to be £486,198 as against £199,042 earned by the eight railway-owned canals of the United Kingdom, the mileage of the former being 687 and of the latter 693, while their respective earnings as toll-takers are £221,344 and £80,804. An examination of the individual earnings of the canals in the two classes shows that while, as might be expected, the revenue earned by the railway-owned canals as toll-takers is, with only two exceptions,* considerably above that earned by them as carriers, exactly the reverse is the case, with one exception,† with the independent canals. Thus the Aire and Calder earned £121,775 as carriers and only £67,835 from tolls; the Leeds and Liverpool £94,464 as carriers as against £43,367 from tolls; and the Trent Navigation £14,115 as carriers and only £1,492 from tolls; while the total revenue of the ten independent canals from freight as carriers is £486,198, and that earned by tolls £221,344. Lastly, if we compare the profits earned by canals acting as carriers with those, whether acting as carriers or not, taking tolls, we find that the total earnings of the eighteen carrying canals of the United Kingdom amount to more than two-thirds of those earned by one hundred and twenty-six toll-taking canals, £685,240 as against £998,844, though the mileage of the former is only 1,380 miles‡ and that of the latter 3,811 miles.

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* This appears to be the only return published on the subject, and the writer is informed that the Board do not intend calling for any other at present.

Setting aside the complex question as to the advisability of traders competing with companies as carriers on canals, which is, of course, governed in many cases by the conditions of the incorporating Acts, the above facts seem to show that where—as in the case of the Aire and Calder, one of the most prosperous canals—a canal company controls an important through route, the carrying-trade may be made as remunerative on canals as on railways.

3. The desirability of a clearing-house for canals is so obvious and has been so generally admitted, that it is scarcely necessary to enlarge on the benefits which the railway companies have derived from this branch of their organization. In the case of the latter, its establishment seems to have followed as a necessary consequence of the foundation of the great trunk-lines, and it can scarcely be doubted that if some half dozen of our through routes by water were made worthy—which they can scarcely be said to be now—of the appellation, and a brisk carrying-trade were developed upon them, it would lead to a similar result. The establishment of a clearing system for canals was expressly provided for under section 44 of the Railway and Canal Traffic Act, 1888, and its merits have been fully demonstrated in a report to the Lancashire and Cheshire Conference on Railway and Canal Rates by their counsel, Mr.

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* The Chesterfield canal and the Shropshire Union canals. It is to be noted that the latter is not an ordinary railway company, but a canal and railway company.

† The Rochdale canal, which was at one time leased to railway companies and became independent about 1875.

‡ Tables showing these details are contained in the Appendix.

Waghorn, in the autumn of 1892, as well as in two able articles published in the November and December numbers of the *Canal Journal* (a periodical which unfortunately has ceased to exist) for that year. Until it is created neither canal companies nor traders can have the full benefits of intercommunication, and it would doubtless serve, as the railway clearing-house has done, as a means for settling disputes in a friendly spirit without having recourse to law. It would thus provide a basis for securing combination and concerted action among canal companies, and without these it seems hopeless for them to attempt to compete with railway companies, which are constantly manifesting an increased tendency to recognize the benefits of co-operation.

In concluding this paper, for the length of which an apology is due to the members, the writer may reiterate the conviction that private enterprize fostered by means of co-operation, not only between the companies themselves, but also with the trading community, which is scarcely less interested than canal-owners in making canals a real counterpoise to railways, offers the only efficacious remedy for renewing the arrested development of our waterways.

APPENDIX A.—CANALS DOING BUSINESS AS CARRIERS, SHOWING THE COMPARATIVE REVENUE DERIVED FROM FREIGHT AS CARRIERS AND FROM TOLLS OF INDEPENDENT CANALS, AND CANALS OWNED BY RAILWAYS RESPECTIVELY.

INDEPENDENT CANALS.

Name.	Mileage.	Revenue from Freight as Carriers.	Revenue Derived from Tolls.
ENGLAND AND WALES.		£	£
1. Aire and Calder navigation ...	93	121,775	67,835
2. Glamorganshire canal	25	4,111	4,053
3. Leeds and Liverpool canal ...	143	94,464	43,367
4. London and Hampshire canal ...	37	1,268	78
5. Manchester ship-canal	75	192,479	76,332*
6. Rochdale canal	34	4,794	19,394
7. Trent navigation	68	14,115	1,492
	475	433,006	212,551
SCOTLAND.			
None.			
IRELAND.			
1. Barrow navigation	43	5,032	1,992
2. Grand canal	165	47,600	6,801
3. Strabane canal	4	560	Nil.
	212	53,192	8,793
Total of the United Kingdom. .	687	486,198	221,344

CANALS OWNED BY RAILWAYS.

Name.	Mileage.	Revenue from Freight as Carriers.	Revenue Derived from Tolls.
ENGLAND AND WALES.			
London and North-Western Railway Company—		£	£
1. Shropshire (Coalport) canal ...	20	70	455
2. Lancaster canal	72	2,087	7,094
Manchester, Sheffield, and Lincolnshire Railway Company—			
3. Ashton canal	70	10,908	12,981
4. Peak Forest canal	70		
5. Macclesfield canal	70		
6. Chesterfield canal	72	2,793	1,442
North Staffordshire Railway Co.—			
7. Trent and Mersey navigation	119	4,238	53,454
Shropshire Union Railway and Canal Company—			
8. Shropshire Union canals ...	200	178,946	5,378
	693	199,042	80,804
SCOTLAND.			
None.			
IRELAND.			
None.			
Total of the United Kingdom...	693	199,042	80,804

* Including dockage.

APPENDIX B.—COMPARATIVE MILEAGE AND REVENUE OF CANALS ACTING AS CARRIERS, AND OF CANALS ACTING AS TOLL-TAKERS.

Country.	Canals acting as Carriers.			Canals acting as Toll-takers.		
	No. of Canals.	Mileage.	Revenue as Carriers.	No. of Canals.	Mileage.	Revenue from Tolls.
ENGLAND AND WALES.			£			£
Independent canals	7	475	433,006	61	2,025	741,096
Canals owned by railways ...	8	693	199,042	50	1,024	174,570
	15	1,168	632,048	111	3,049	915,666
SCOTLAND.						
Independent canals	None	—	—	2	69	9,429
Canals owned by railways ...	None	—	—	2	84	48,729
	—	—	—	4	153	58,158
IRELAND.						
Independent canals	3	212	53,192	10	513	20,912
Canals owned by railways ...	None	—	—	1	96	4,108
	3	212	53,192	11	609	25,020
Total of the United Kingdom ...	18	1,380	685,240	126	3,811	998,844

The following paper by Mr. J. Stephen Jeans on "The Comparative Conditions and Costs of Transport by Railway and Canal," was taken as read:—

THE COMPARATIVE CONDITIONS AND COSTS OF TRANSPORT BY RAILWAY AND CANAL.

BY J. STEPHEN JEANS, MEMBER OF THE ROYAL INSTITUTION OF GREAT BRITAIN, M.I. AND S. INST., F.S.S., AUTHOR OF "RAILWAY PROBLEMS," "WATERWAYS AND WATER TRANSPORT," ETC.

The subject of canal transport is one that must always be present to the coal-owner, the colliery manager, and all who are in any way, directly or indirectly, concerned in the great business of transportation—a business that yields to the railway companies of this country, in respect of mineral traffic alone, about 16½ millions sterling a year, or nearly one-third of the total value of the coal output at the pits' mouth in the year 1893.

In these days of close competition, both home and foreign, it is natural that traders should seek by every means in their power to come to closer quarters with the railway companies in the matter of cost of transport. To avoid the payments entailed upon them under this head, many of the largest colliery owners have constructed their own railways or tramways, have built their own ports, harbours, or docks, have established their own lines of steamers, and have undertaken other enterprises that have more or less enabled them to become independent of the great main lines of railway-communication, and to place their produce on the market at the lowest possible cost. Nevertheless, the difficulties of reaching some of the principal markets are still so serious as to call for the most anxious care and solicitude. The average cost of coal at railway-depôts in the metropolis is much more than twice its cost at the place of production. The average cost of coal and coke at ironworks on the west coast is nearly twice as much as the cost at the pits and ovens in South Durham, and for that reason the iron and steel industries of West Cumberland and North-West Lancashire have long been in a more or less unsatisfactory condition. The low cost of placing coal f.o.b. in Cardiff docks has exalted that port to the foremost place among the great coal-shipping ports of the world, and has secured for it an unique position in reference to volume of exports. The high cost of coal has destroyed the manufacturing activity of numerous centres of population that were formerly hives of industry, including even the metropolis itself. In short, the cost of coal very largely determines the prosperity or otherwise of communities, and the cost of coal, in its turn, is determined by the difference between the prices charged at the place of production and at the place of consumption.

The traders and manufacturers of this country have for many years endured a permanent and apparently irremovable grievance in the high cost of railway transport. This grievance formed the subject of many days of discussion and enquiry while the maximum schedules of rates and charges and the proposed statutory classification under the Railway and Canal Traffic Act of 1888 were before the Board of Trade, and afterwards before the hybrid committee by whom they were ultimately fixed. The traders submitted many lists of rates and charges, tending to show that although the coal traffic was the backbone of the business carried on by the railway companies, the rates charged for carrying it on were much higher than they should be, rising sometimes for short distance traffic to 1½d. per mile, or six times as much as it ought to be. Even the London coal traffic was seldom carried for less than ½d. per mile, although the cost of the service, excluding interest on capital, was considerably less than one-half of that amount.

The traders have long sought relief from the high charges on coal traffic by casting about for ways and means of more fully utilizing canal navigations. Drowning men clutch at straws, and we can hardly regard the existing system of canals in this country as much better than straws, and those too of the weakest. A few of the canals are able to carry a relatively considerable volume of traffic, but as a rule, the canal-system makes a wretchedly poor show alongside of the railways, alike in the matter of extent and value of traffic, facilities, methods, and working arrangements generally, while the writer is by no means certain that they offer substantial inducements in the matter of cheaper transport.

The city of Birmingham, in which we are now assembled, has not only been largely the cradle of the canal system, but is, even to this date, a foster-mother to water-navigation for heavy traffic. The Birmingham canal navigations are among the most extensive in the whole country, and carry altogether nearly eight millions of tons of traffic, which is more than three times the tonnage carried by the Aire and Calder canal, the next most important system. Nor is the Birmingham system without interest from other points of view. The Netherton and Dudley tunnels—the former 9,081 feet and the latter 9,516 feet in length—are sufficiently notable to be classed among the great engineering works of an earlier day, and so also with the Lappal tunnel which extends to 11,385 feet in length.

These works must have taxed the resources of the constructive minds of the last century much more severely than more wonderful works would be likely to do at the present day. So also with the reservoirs that feed the Birmingham canal system, six in number, and one of them with a capacity of 105,000,000 cubic feet.

According to the Canals and Navigations Returns for 1888, the total capital paid up and raised from all sources in respect of the canals of the United Kingdom, not belonging to railway companies, was 24¼ million pounds, or about £9,300 per mile. Some 1,204 miles belonging to railway companies do not show the cost, which is mixed up with that of the undertakings to which they belong, but if we assume the same average, which is likely to be rather over the mark, we should have 11 millions more, bringing up the total capital outlay on the canal system to 35¼ million pounds, which coincides very closely with 20s. of capital per ton of annual traffic carried. Measured by the same test our railways should show a capital expenditure of about 300 millions sterling, whereas the actual capital outlay has been more than three times that amount.

If the canal system could provide for the same density of traffic it would manifestly be much the cheaper system of the two. But as it cannot do this, we are bound to assume that it labours under a disability which is not easily removed.

The canals of Great Britain are not only inefficient, but like most men and things that fail in efficiency, they are not over well rewarded in the matter of profits. The total net profits derived from the canals in the hands of private companies, as distinguished from railway companies was some £592,000, equal to the payment of a dividend of only 2·4 per cent. on the paid up capital. On the railway systems as a whole, the net receipts amounted in 1893 to £34,936,000 and was equal to the payment of 3·60 per cent. on the invested capital, the average for 1888 having, however, been 4·06 per cent.

Comparatively few people stop to enquire as to the amount of the toll which the railway companies are accustomed to take from the inhabitants of these islands in the form of transportation-charges. It now amounts to over £2 per head of the entire population. It is more than four times as much as the total local taxation of the kingdom. It is almost as much as the total amount of the national income for State purposes. It is more than the total value of the total mineral produce of all kinds, including coal. It is nearly as much again as the total rent of the country for agricultural purposes, and it is nearly a tenth part of the estimated income of every class of the community.

In order to pay a 5 per cent. dividend on the capital of the English railways, a sum of £2,600 would have to be earned per mile per annum, whereas a sum of less than £500 per mile would suffice to pay the like dividend on canal expenditure. Even so, however, it is important to bear in mind that the capital invested in our canals, as measured in this way, is almost as large as that expended on some important systems of railway mileage. The average expenditure on American railways, as ascertained by dividing the mileage constructed into the total amount of capital now entered against the system, works out to close on £12,000 per mile. Mr. Poor, the well-known railway expert, has stated again and again that nearly one-half of the total amount was pure water, and that up to a comparatively recent date the capital actually expended did not exceed £7,000 per mile, except in a very few localities.

The late Mr. E. R. Conder had perhaps an exaggerated idea of the extent to which the canal system of this country might be utilized, but he had no doubt as to the greater cheapness with which traffic could be carried by canals, as compared with railway transport. In a calculation which he submitted to the Select Committee on Canals,* he estimated that the actual cost of working the traffic carried on the railways of the United Kingdom was not less than 0·53d. per ton per mile, and to this he added 0·78d. per ton per mile in respect of interest on capital invested, making a total of 1·31d. per ton per mile for both items, and a total cost per 100,000 units of £587. On the other hand, he estimated that, with a similar volume of traffic, the cost of canal transport in England would only be 0·37d., including 0·11d. for interest on investment, or £154 per 100,000 units. In other words, he estimated that the cost of railway transport would be at least three and a quarter times as much as the cost of canal transport. Of course, the cost of carrying mineral traffic would in both cases be much less, although it is curious to note that the railway companies have never appeared to be over-ready to give exact information as to what that cost actually is. The late Sir James Allport, who ought to have known, as the manager for many years of the Midland Railway Company, stated that the cost of transporting mineral traffic on that system—assuming 42 trucks or 336 tons of minerals to a train—was 2s. 6d. per train mile, including everything,† which would, of course, bring down the actual cost of haulage to 0·089d. per ton mile, or 0·178d. per ton mile, including return empties. This is, in short, assumed to be a generally approximate figure for mineral traffic in English railway working. On three of the principal English railways, so far back as 1865, the ascertained cost of working mineral traffic varied from 2s. 6·6d. to 2s. 10·7d. per train mile,* while the cost per ton mile would, of course, vary with the extent of the paying load. The same figure was accepted by the late Sir George Findlay and other railway experts in giving their evidence before the Board of Trade Commission on Railway Rates and Classification in 1889. To this we must add the amount required to meet the interest charges on capital, which we have already shown to amount to £2,600 per mile of railway opened, but which we cannot easily apportion in relation to merchandize train-mileage, owing to the difficulty of separating the goods and passengers' apportionment of expenditure.

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* *Report*, 1883, page 233.

† *Select Committee on Canals*, 1883, page 83.

To an institution like The Federated Institution of Mining Engineers, which is mainly concerned in the production and distribution of coal, no question can be of greater importance than that of cheap transport of the mineral which it is the province of its members to produce and that of the public to consume. Unfortunately, in Great Britain, we are handicapped in this matter to a greater extent than is any other country of industrial importance. The last published report of the Inter-State Commerce Commission of the United States purports to show to what extent we are handicapped in the cost of transportation as compared with other and competing countries. It states that whereas the average ton-mile rate in the United States is under ½d. per ton per mile for all descriptions of traffic, the average rate for the United Kingdom is not less than 1¼d. per ton per mile, and the average for France and Germany comes in between the exceptionally low rates of the American railways and the exceptionally high rates of our own country.†

One of the differences that distinguish English railway administration, in its relations with traders from those of other countries, is the comparatively small reduction that has been made in railway rates and charges of late years, notwithstanding the great economies that more scientific and intelligent methods have enabled railway managers to undertake. This is a permanent and a just grievance with the large traders. Improvements in all mechanical appliances and methods, in systems of grading and permanent way, in the cost and efficiency of locomotive engines, in the consumption of fuel, in the control of trains by brakes, etc., which have enabled the numbers of men needed to safely manage a train to be reduced—all these and other sources of economy should be reflected in the cost and incidence of railway charges, and so they are in all countries except our own. It is the same with the capital expenditure relatively to the mileage constructed. In Germany, France, Belgium, Italy, and most other countries, the average capital outlay per mile of line opened has been reduced during recent years, whereas in this country it has been not only sensibly, but enormously increased. Under these circumstances it is scarcely a matter for surprise that traders are discontented.

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* *Report of the Duke of Devonshire's Commission on Railway Working.*

† It is, however, important to bear in mind that English railway statistics do not afford any data as to ton-mile rates, and the railway companies have always professed that they had not the information, so that the average given by the Inter-State Commerce Commission must be largely guess-work.

There is no record of the average distance over which mineral traffic is carried on either railways or canals. It is a pity that the Board of Trade, in getting out the returns of canal traffic, did not ask for particulars of the ton-mile traffic, and if they had also obtained some particulars of the descriptions of traffic carried it would not have been amiss, seeing that no details are available as to how much was minerals and how much took the form of other goods. It is, however, more than probable that three-fourths at least of the traffic carried on the canals was mineral traffic, while we know that 208 millions of the 293 millions carried on the railways in 1893 was mineral traffic. These things being so, it is interesting to find that the average receipts per ton carried on the canals was 1s., while on the railways it was 1s. 6d., showing, as far as they go, that mineral traffic is either carried for shorter distances on the canals or is subject to the payment of lower charges. It may be added that where the average gross receipts per mile of line open on the railways was £3,722, it was on the canals only £710 in England and Wales; and that while the proportion of expenditure to receipts was 57 per cent. on the railways (in 1893), it was 59·8 per cent. on the canals of England and Wales.

The United Kingdom, although liberally endowed by nature with facilities for shipment and with other obvious natural advantages, is quite destitute of the remarkable resources for inland transport possessed by some other countries, and more especially by the United States. In the latter country the southern coal-fields have access by the great Kanawha river to the Ohio and the Mississippi rivers, giving over 16,000 miles of inland navigation. On these rivers and their tributaries we meet with what we would like to regard as ideal coal rates. It is usual to tow coal cargoes from Charlestown to Cincinnati, a distance of 263 miles, for 1s. 0½d. (25 cents) per ton, excluding barge hire. From Charlestown to New Orleans the distance is 1,776 miles, and the rate for towing and hire of barge is 5s. 2½d., or 0·035d. per ton per mile. From Cincinnati to the mouth of the Kentucky river at Louisville, a distance of 394 miles, the rate, including towing and rent of barge, is 2s. per ton. But on the Ohio river, the tow-boats often take from 13 to 34 loaded barges, or about 15,000 tons of live-load, which is a condition of things that does not and could not well exist in this country. In short, when we look at these American rates we can only wonder, envy, and think of the things that might have been.

It is, however, much the same, *mutatis mutandis*, with canal and railway traffic. In both cases the rates are very much below what we have any knowledge of in this country. The State of New York alone has expended some 70 millions of dollars, or roughly 15 million pounds on canal construction and improvement. In 1873, the average rate on the New York State canals per ton of traffic carried was 0·44d. per mile, but in 1881 the rate had dropped to 0·19d. per ton per mile, and after 1882, when the tolls were abolished, the rates were often lower still. These rates, low as they are, appear to be relatively high when compared with some of the rates paid on the railways of the same country. In 1892, the average ton-mile rate on the Philadelphia and Erie system was only 0·22d., and on the Chesapeake and Ohio, in the same year, the average was only 0·25d., on the New York Central it was 0·35d., on the Pennsylvania 0·28d., on the New York, Lake Erie and Western 0·30d., and on the Lake Shore and Michigan Southern it was only 0·29d. Some of the railways had, of course, a much higher average than those just quoted, but the official average ton-mile rate on the railways of the United States as a whole in 1890 and 1891 did not exceed 0·47d., while in 1893 the average was only 0·44d. per ton per mile. In the German Railroad Union for the same year the average ton-mile rate was 0·67d., to which figure it had fallen from nearly 1d. ten years ago. In Belgium the railway rates are much the same as in Germany, and in France they are close on 1d. as an average. In all these countries the railway rates have undergone considerable modification during recent years. In the United States, indeed, had the rates current in 1865 to 1869 been maintained over the last ten years the railways of that country, as a whole, would have earned £200,000,000 a year, or £2,000,000,000 for the whole period, more than they actually did earn. These immense figures indicate the great magnitude of the problem of cheap transportation. The reduction of rates on the American railroads between 1869 and 1893, on the traffic of the latter year, would represent an annual saving to freighters of considerably more than twice the amount of our total national expenditure, or nearly three times the amount of the total gross railroad earnings of this country.

It is only when we marshal and consider figures like these that we realize the vast importance to the trade of the country of the issues involved in this question. It is not for a moment pretended that the cases are parallel. We could not expect, under any circumstances, to have rates so low as those current in the United States, where the average haul is quite three times as much as in our own country, where the facilities are not nearly so abundant, and where the gradients over a large area are almost *nil.* But it is certainly of the utmost moment to our trade and commerce to learn that Germany, a country with much more nearly parallel conditions, has an average ton-mile rate of only 0·67d., or not more than one-half of that which is understood to prevail in Great Britain.*

It has probably not often occurred to the members of this Institution to consider what sort of millenium they would enter upon if we had the command of as cheap rates of transport as they have in the United States. With ½d. average ton-mile rate, our payments to the railway companies would fall from over £40,000,000 a year to less than half of that amount. In other words, our bill for transport would be reduced by a sum that would be more than equal to the aggregate value of our annual exports of coal and coke. This is a prospect that is manifestly too good to be realized. Its realization would practically mean the ruin of British railway investments, which now yield only about £35,000,000 of annual net receipts from all sources. The existing railway *régime* durst not attempt anything of the sort, even were they so minded, nor is it probable that, even with the cheapest conditions imaginable for railway transport, our economic circumstances could be brought to the same level as those of America. It would not be fair to forget that the conditions of working in the two countries are greatly dissimilar. In the United States, the average length of haul exceeds 110 miles, whereas in this country it is not more than 35 miles, if quite as much even as that. In the United States, again, the custom is to have very heavy train-loads, up to 2,000 tons, whereas in this country a load of 350 tons is rather exceptional. This, of course, means that in the United States the railway companies have relatively small handling expenses, and as they carry heavy loads for long distances, they can make use of very much larger waggons and trucks than we can, which saves tare and facilitates economical working.

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* The writer is aware that the rates on coal traffic, both for London and for local consumption on a large scale, are often under ½d. per ton per mile, but we have to deal with the average of the whole country in both cases, and not with particular rates or classes of rates.

It is, however, quite on the cards that some economies could be introduced into the working of English railways, although the writer would not dogmatize on this point. The railway companies are naturally interested in working their traffic as economically as possible, consistently with providing traders with all the facilities which they require, and which are unquestionably afforded to them in a larger measure than is common in other countries. That consideration does not, of course, affect the traffic in which we are specially interested, so much as it does traffic of a more miscellaneous character. In the working of general traffic, time is usually a matter of supreme concern. In the working of mineral traffic, so long as deliveries are properly and systematically regulated, time is not of such great importance. This is the consideration that causes mineral traffic to be so much more largely carried on canals, and suggests to our traffic reformers whether much more might not be attempted in this direction.

The late Mr. Abernethy calculated that it would cost £12,000 per mile to put the canal-system of this country into a good serviceable condition, so as to be of any real use to the country, and capable of offering serious competition to railway transport, so far as they went. This would mean that nearly £46,000,000 would have to be expended on the existing system of 3,813 miles. It is more important to the coal trade than to any other interest to consider whether the game is worth the candle. The sum is large, but the railway companies have added nearly four times as much to their capital expenditure during the last ten years, so that there would seem to be no insuperable obstacle to the money being provided, if the end were to justify the means. An essential preliminary would, however, be that the most careful enquiries should be made as to the lowest cost at which canal transport could be effected under the altered conditions, with large boats, with electric and steam traction, with improved locks, and possibly also with a modified system of tolls.

From the figures, which had been supplied to him by the inventors, it would seem that the recently invented Thwaite-Cawley system of canal-haulage would be worth the careful consideration by those interested in economical canal transport. These figures—which it is stated are based upon data derived from actual practical working—show the cost of horse-power, per 12 hours day, for haulage purposes to be as follows :—

	s.	d.
Electrical haulage (Thwaite-Cawley system) ...	1	0
Steam-tug haulage	1	8½
Horse-haulage	3	11¼

The figures given for the steam-tug haulage are below the actual cost, as the damage to the canal banks from steam-boat traffic has not been taken into account in the above relative estimate, and the cost due to such damage is, in some cases, very considerable. Farther, it has been assumed that the steam-tug always works at its maximum capacity. For light cargoes the steam-tug haulage cost would be increased.

If under the new conditions the canals could carry the great mineral traffic in anything like large bulk, at a rate not exceeding ¼d. per ton per mile, then the enterprize might be worth initiating.

One of the schemes that are at present *in nubibus* in this district is that of converting the Worcester and Birmingham navigation into a ship-canal, so that, as a continuance of the Severn scheme, steamships of 400 tons burthen would be able to pass from tidal water into Birmingham without break of bulk. The length of this navigation is 30 miles, and estimates have been furnished to carry out the work for £603,300, but whether the cost be less or more it would seem to be well worth trying. This measure, however, at the most would only relieve a comparatively small part of the coal industry of the country, and it would depend upon the extent of the traffic that could be put on the canals between Birmingham and the sea, whether it would relieve even that. One thing only is certain, namely, that the Birmingham and Midland traders generally are in great straits, in consequence of their relatively great distance from the sea. It is desirable to minimize as far as possible the inconveniences of the geographical situation of the Midland capital from this point of view. The railway companies either cannot or will not give additional assistance to this end. They are accustomed to charge from 10s. to 15s. per ton for transport of heavy traffic to London, while the cost of transport of like traffic from Liége to Antwerp, an approximately similar distance, is between 4s. and 5s. per ton, and from the Westphalian coal-field to Antwerp or Rotterdam very little more. In these circumstances, the Midland traders must work out their own salvation—not necessarily in a spirit of hostility to the railway companies, but in the spirit of the commercial principle which compels us to buy in the cheapest markets. England cannot afford to have it said that the manufactured goods in which this district so greatly excels can be delivered in Lancashire from Belgium and Germany more cheaply than they can be carried from Birmingham, which is only about one-third of the distance, and yet that is the anomalous position in which the staple trades of the Midlands are placed at the present time.

One of the most pertinent questions presented for solution in the consideration of this subject is that of the lowest cost at which traders can expect to have their traffic carried by water.

There are many facts available to guide us to a conclusion on this point. Take the experience of the United States as an example. Probably the most important movement of traffic in that country is that of wheat from Chicago to the sea-board. The railway rates have always been kept extremely low by the competition of the waterways between these two important distributing centres. There is no record of the all-rail rates up to the year 1868. Up to that date, the traffic was carried almost wholly by water, and the rates varied from a minimum of 16½ to a maximum of 29½ cents per bushel. The first average all-rail rate quoted was 42½ cents in 1868. Water competition brought the rate down to 24 cents in 1875, and to 14 cents in 1885. Meanwhile the water rate continued to drop cent by cent, until in 1892 it reached what almost appears to be an irreducible minimum at 5·61 cents. For the last ten years the all-water rate has been considerably less than one-half of the all-rail rate for the same service. The one system regulates and determines the charge on the other, and traders reap a great advantage thereby. The experience of the Aire and Calder navigation, with the most modern conditions of canal-transport, proves that heavy traffic can be carried on canals for an almost incredibly low figure. Mr. Bartholemew told the Select Committee on Canals in 1883, that the cost of transport on that system was only 0·03d. per ton-mile. It must not, however, be assumed that this is a typical figure. Canal rates have hitherto often been as high as those on English railways. On canals between Birmingham and London, under railway control, the average rate per ton per mile was stated to be 1·40d., but this was due to the railway administration. On the Grand Junction canal, which is an independent route, the average rate for the same service was only 0·35d.* and there is good reason to believe that this average rate might be still farther reduced if the conditions were made more favourable.

Mr, LIONEL B. WELLS (Manchester) read the following paper on "Canals":—

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* *Report of the Select Committee on Canals*, 1883, page 253.

See Map in end pocket.

CANALS.

By LIONEL B. WELLS, M. Inst. C.E.

Canals, the generic term for all inland waterways in this country, is to the writer a very interesting subject, and one which has occupied much of his time during the last eighteen years. In 1877, he was appointed engineer to the River Weaver navigation, and found that extensive works were in progress for the improvement of that important waterway between the town of Northwich and the estuary of the Mersey. It became his duty to complete these, and to design and execute other works for the improvement of the upper portion of the river from Northwich to Winsford. The state of the navigation may be judged from a paragraph in Sir Charles Hartley's lecture on inland navigation, given at the Institution of Civil Engineers in 1885, in which he referred to the Weaver navigation as "the best study in England at present of modern canal appliances." The writer mentions this because he is addressing practical men, and he feels that whatever he writes would be more interesting if they learnt that he had practical experience in works of inland navigation.

The general question of "Canals" now under consideration is very difficult to deal with, owing to the lack of reliable information and statistics upon the subject.

The Blue Book published in 1890 giving returns for the year 1888 contains the latest and most detailed information available arranged for reference. The Board of Trade are quite aware of many of its defects. It is a serious matter to find the errors therein, quoted as a correct exposition of the facts relating to our canal-systems, not only in British but also in foreign publications, and although these figures have been published for four and a half years, they are still adopted by persons writing for the information of the public on the question. In the *Times* of May 16th, 1894, a long article headed "Our Canals" commences by stating how meagre was the information on the subject, it being confined to a map published in 1852 by the Government on the motion of Mr. Richard Cobden, the proceedings of Mr. Salt's committee in 1883, which, by-the-way, never completed its labours or made even an interim report, and the Report of the Society of Arts Conference in 1888; and then refers to the

Blue Book above mentioned, C—6,083, 1890, and adopts the figures contained therein. As a warning to those who may be inclined to rely too much on the information given in this Blue Book the writer will mention a few of the errors that he has noticed with respect to the canals of England and Wales.

The Blue Book states the total length to be 3,050 miles instead of 3,520 miles, made up of 2,026 miles of independent and 1,024 miles of railway-controlled canals, as against 2,256 miles of independent and 1,264 miles of canals controlled by railway companies; the important Gloucester and Berkeley ship-canal being one of those omitted.

The information to be gleaned from the returns of capital expenditure is equally delusive. The paid-up capital of the Wilts and Berks canal, 69 miles long, is entered as £19,441, whereas it probably cost £500,000; and the Weaver Navigation £265,000, which was the amount of the terminable annuities unpaid in 1888, and has since been reduced to £200,000. The return has been frequently used for the purpose of finding the cost per mile of the canals in this country. The writer does not suppose that it was intended to be applied to such a purpose, but there was no hint given that the total capital account ought not to be divided by the total mileage to arrive at the cost per mile.

As the writer could not find a satisfactory map of English waterways he has endeavoured to supply the want as well as circumstances permit, but he feels sure that there must be many omissions, and he should be very glad to receive information which would enable him to make it more accurate. The map (Plate XXV.) was prepared with the help of a friend (Mr. Swindells, M. Inst. C.E., F.R.G.S.) for the International Congress on Inland Navigation, held at Paris in 1892: no map of English waterways having been forthcoming at the previous congress held in Manchester, when excellent maps of the systems existing in foreign countries were exhibited. The original map is drawn to a scale of $\frac{1}{437,200}$ or 6·9 miles per inch. Plate XXV. is reproduced to one-fourth of the scale of the original map. The map shows all the existing inland waterways that the writer has been able to identify in full lines. The independent ones are indicated by blue lines, and the railway-controlled canals by red lines. The canals converted into railways, and those that are derelict or abandoned are shown by dotted lines.

A blight fell upon our canals soon after the advent of railways, and, unlike the French who seized the opportunity to acquire many of their canals for the State, our Government allowed one-third of the canal-mileage to be handed over to the railway companies. In the year 1846, 776 miles of waterway passed by Act of Parliament under the control of railway companies, and at the present time, as already stated, 1,264 miles of navigation out of 3,520 miles are in their hands. In addition to this length, 140 miles have been converted into railways and 275 miles are derelict or abandoned. The mischief done does not cease there, for the railway-owned canals are frequently so situated that they break the line of through communication on the most important routes.

These points are made clearer by an examination of the map than by any written description. It shows how the through routes between London and Liverpool, London and Bristol, Birmingham and Liverpool, and Birmingham and the Humber are shorn of their independence. The company having the greatest mileage and the greatest pecuniary interest in inland navigation is the London and North-Western Railway Company, the greatest and most powerful rival to its prosperity. This company controls six canals having a total length of 460 miles. The Great Western Railway Company owns twelve canals, aggregating 260 miles; altogether forty-three waterways, having, as above stated, a length of 1,264 miles, are controlled by thirteen railway companies. There are upwards of one hundred and thirty different lengths of waterways and more than one hundred proprietors.

The waterways of England fall geographically into six groups. Five of these are connected with estuaries, viz., the Humber, Mersey, Wash, Thames, and Severn. The sixth centres round Birmingham; there are outlying canals along the coasts, but few of these are of any importance.

The canals connected with the Humber are all barge-canals, and among them is the Aire and Calder, the most successful of our inland navigations. The Humber group is connected with the Mersey by means of the Aire and Calder, and the Leeds and Liverpool; another route connects the two rivers by means of the Aire and Calder, Calder and Hebble, Rochdale, and Bridgewater canals. The Leeds and Liverpool and the Rochdale canals are now independent, but they were for many years under railway control, and the locks being of different sizes constituted a hindrance to the free exchange of traffic. There is a third line to Liverpool, by way of the Huddersfield, Ashton, Rochdale, and Bridgewater canals, but two of these are narrow-boat canals and owned by two railway companies.

Although there is less railway influence felt in this than in many other groups, the ill effects due to our want of a system in canal matters are very evident, especially along the shorter routes, viz., difference in size of locks, in depth of water, and four ownerships in a distance of 117 miles from tideway to tideway.

To the south, there is a connexion between the Humber and the Thames by way of the Trent and five other canals, one of which is narrow, and has hitherto been a block to through communication by barges. We shall see later that a step has been taken towards amalgamation on this route.

In mentioning the Mersey group, reference must be made to the Manchester ship-canal, but simply to remark that this is primarily for sea-going ships, and cannot properly be classed as an inland navigation. It is, however, used by barges, and although its tonnage and traffic receipts are not so great as its more ardent supporters prophesied, still there is a substantial use made of the canal, which is increasing every month, and the benefits conferred on Manchester and the neighbourhood in the shape of reduction of railway rates has already been very considerable. In alliance with the Manchester ship-canal is the Bridgewater, the most successful of our shallower barge-canals. In the Mersey group are also the Weaver, Trent and Mersey, and the Shropshire Union canals. The last two are railway-owned, and they form the only connexion with Birmingham and the south.

Around Birmingham, the canals are all narrow, and to a great extent owned by railway companies. There is, however, an independent route to the Severn, and although hitherto there has not been a heavy traffic carried along it, it has been useful in keeping railway rates in check, the rates from Bristol and South Wales being lower in proportion to the distance than the rates from Liverpool, while the Gloucester and Berkeley canal has materially added to the prosperity of Gloucester and the Midlands.

From the Severn to the Thames the present condition of inland navigation is deplorable. There are two distinct routes, one by the Stroudwater, Thames and Severn, and river Thames, and the other by the river Avon, Kennet and Avon canal, and rivers Kennet and Thames. The Great Western Railway Company own a portion of each route. The one by way of the Thames and Severn canal is practically closed, while the Kennet and Avon canal has become shallow for want of dredging, and the use of steam is prohibited on it, the Board of Trade supporting the railway company in maintaining this prohibition. These canals are both barge-canals.

There is a narrow canal, the Wilts and Berks, between the two, but this joins the railway-owned Kennet and Avon, and is much in need of repair. A movement is on foot for taking the Thames and Severn canal out of the hands of the railway company and vesting it in the neighbouring navigations.

From the Thames, that is to say London, to the north-west or Mersey and north-east or Humber groups, the only practicable route is by way of the Grand Junction canal, one of the five already mentioned as forming a connexion between the Thames and the Humber. This is a barge-canal, in good working order and able to pay a fair dividend, although it follows the course of the London and North-Western railway and hitherto has had no northern terminus of any value. It communicates with Birmingham by means of the Oxford, Warwick and Napton, Warwick and Birmingham, and Birmingham and Warwick Junction, all narrow canals, and to the north over the Grand Union, and the Leicestershire and Northamptonshire Union to Leicester, thence by way of the Leicester navigation, and Loughborough canal, to a junction with the Trent.

The group connected with the Wash are all river navigations, but being in a country where drainage is of the first importance, navigation interests have not held a high claim to consideration. There are water connexions with the Grand Junction canal by means of a narrow canal branch from Northampton, and with the Trent by means of the Witham and Foss-dyke navigations, both of which are owned by railway companies. The condition of the Ouse from St. Neots to Earith was investigated by Major Marindin, an inspector from the Board of Trade in 1890, and its condition was reported to be deplorable. The locks had fallen into decay, not only the timber-work but also the brickwork and masonry, while the drainage of the valley was impeded by weirs and other obstructions. It was found that no less than seven public bodies were concerned in the river, and had power to obstruct any alterations.

In connexion with the Ouse and its navigable tributaries there are at least nine toll-taking bodies. It can be readily understood that under these conditions navigation is at the lowest ebb. Indeed the collapse has been so thorough that sufficient energy was not left to enable several of the commissioners to make the return required at their hands in 1888. The writer does not hear, however, that they have ceased to take toll from any trader who tries to pass their way. Since 1888, there has been a revival of interest in navigation in Fen-land, and money is being spent in improvements on the Ouse, while the Lark has been again restored as a navigation for lightly-laden barges.

Having regard to their dimensions the canals of England and Wales may be divided into five classes.

	Miles.
(1) Narrow boat-canals, aggregating about	1,240
(2) Shallow barge-canals	2,040
(3) Improved barge-canals, 6½ feet deep and upwards	230
(4) Ship-canals, 13 feet to 18 feet deep	23
(5) Manchester ship-canal	35½
Total	3,568½

(1) The dimensions of the locks of the narrow canals in England vary, and provide for boats differing in length from 71 feet to 81 feet, with beam varying from 6 feet 4 inches to 7 feet 2 inches. The depth of water also varies. The cargoes may be placed at from 18 to 30 tons.

(2) The small barge-canal locks accommodate vessels differing still more in dimensions, and the barges carry cargoes varying from 40 to 60 tons.

(3) The improved barge-canals accommodate craft carrying from 90 up to 350 tons; this weight has been taken in one cargo on the Weaver, and the locks will accommodate a train loaded with 1,000 tons.

(4) Ship-canals are short and of no present importance, except the Gloucester and Berkeley, which has a large traffic.

(5) Manchester ship-canal.

Although no statistics exist, so far as known to the writer, of the tonnage carried on canals in former days, he thinks we may be very sure that it is the one description of traffic that has stagnated in most, and retrograded in many instances in this country. There are a few prosperous companies in different parts of the kingdom, proving that it only requires skill, enterprise, and commercial ability to make this means of conveyance a success in many other localities. The tonnage of shipping entering our ports per head of population is threefold what it was forty years ago, and during that time the population has nearly doubled in number, therefore to supply our wants six times as much transport is required as in 1850. These figures help us in some degree to realize the enormous additions made year by year to the movement of traffic throughout the land. This conveyance has become a necessity for our food-supply and our trade generally, and as the country increases in population and wealth it must continue to grow. The point we have to consider is whether we can move this enormous traffic more economically than at present, and so aid in the general prosperity of the nation. In the commercial world there is no question of greater importance than the cost of transit. Other things being equal, the nation possessing the cheapest means of conveyance must gain the day in the struggle for industrial supremacy.

It is noteworthy that the great advance made by England in manufactures towards the latter part of the last century coincided with the development of canals and river-navigations. In discussing the matter with an American engineer at the last International Congress, he went so far as to say that it was James Brindley who really conquered the Emperor Napoleon. It was largely, he averred, due to the cheapening of transport by Brindley's canals that England prospered as a manufacturing country, became wealthy and able to provide the sinews of war, not only for arming and equipping her own soldiers and sailors, but for subsidizing European nations to fight against the common enemy. Without going so far as this, the writer agrees that our debt to Brindley for assisting our manufacturers and increasing our wealth is very great, and we cannot acknowledge it more suitably than by resuscitating the traffic that has been lost and adding to the amount of traffic on inland waterways for the benefit of our generation and those who come after us.

Grant, for the sake of argument, that we are acting wisely in neglecting canals, at any rate other nations do not continue to practice that policy. On the continent of Europe, as well as in Canada and in the United States of America, great attention is now paid to the question, in spite of the fact that their railway rates are far cheaper than ours.

A correspondent of the *Manchester Guardian*, who has devoted much time in collecting statistics on the movement of traffic within the United Kingdom by rail and water, considers that the weight annually transported is approximately as follows :—

	Tons.
By railways	309,596,000
By canals and navigable rivers	36,300,000
Or for internal transport	345,896,000
Shipped coastwise	25,000,000
Total for home transportation ...	370,896,000

This figure represents about 9 tons per head of population ; but as both on railways and canals the same goods (carried on more than one system) are recorded over again, under the present mode of making returns no means of obtaining accurate information is provided.

The above tonnage compares with 84,000,000 tons of cargo moved in ships trading to the Colonies and to foreign ports.

These figures indicate the enormous quantity of goods moved internally, and point to the paramount importance of our obtaining the best and cheapest means of conveyance, for the aggregate movement of this traffic is 345,896,000 tons per annum. Coastwise and over-sea traffic together reaches 109,000,000 tons, showing that the weight transported by railway and canal is more than three times the united volume of our boasted sea-going and coasting trade, of which we are greatly proud, and to defend which we are ever ready to spend our lives and fortunes.

In an article recently published in the *Contemporary Review** on the "Carrying Trade of the World," Mr. Mulhall gives a number of interesting figures and statistics on the subject. He states that in the last twenty-two years the carrying power by sea has doubled, and traces a relation between the increase of shipping and of railway traffic. He states that the carrying power of the world has increased threefold since 1860, and that the ordinary cost of land-carriage for goods in Europe in 1850 was 8d., whereas now it is under 1d. per ton per mile.

In the last century, the cost of carriage by land to towns in the valley of the Thames to and from London was between 7d. and 8d. per ton per mile. This was reduced to one-half by the use of the imperfect and shallow waterways then provided. These figures confirm the previous statement, that the rates for carriage in this country were much lower than those on the Continent at the close of the last century.

The *Journal des Economistes* states that the ordinary freight charge per ton per mile on railways is as follows:—United States of America, 0·40d.; Holland, 0·78d.; Belgium, 0·80d.; Germany, 0·82d.; France, 1·10d.; Russia, 1·20d.; Italy, 1·25d.; Great Britain, 1·40d.; and the average, 0·97d. per ton per mile.

Assuming that the writer has made an accurate comparison, and that approximately the same services are rendered for the charges quoted, this statement shows that the rates on our railways are 350 per cent. higher than those of the United States and 75 per cent. higher than those of Belgium, a neighbouring manufacturing country.

The average returns of net receipts on railways are given for fourteen countries, from which the writer selects the following:—India, 5·2d.; Germany, 5·1d.; Belgium, 4·6d.; United Kingdom and Egypt, 4·1d.; France, 3·8d.; and the world, 3·2d.

It is noticeable that our net railway receipts are among the highest, and seeing that the volume of traffic is so much greater than in any other country, the income ought to be proportionately large, but unfortunately the want of system in laying out the lines, the great cost of land and preliminary expenses, and the large sums spent in railway construction have so swelled the capital accounts that one looks in vain for any considerable cheapening of the cost of transportation from the railway companies.

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* 1894, vol. lxvi., page 811.

Railway companies do not compete in rates. They are agreed, and the competition commences with a struggle to obtain traffic at the "agreed rate." Many trains are run, which would be unnecessary with due regulation, and large sums of money are spent in canvassing for traffic. The cost of all this has to be covered by the charge for carriage. The only real competition with railways is exercised by independent waterways, on which the public can carry their own commodities. It is impossible to do this on railways, and consequently various kinds of arrangements for making the public pay too much are feasible.

In 1870, the average cost of railways in the United Kingdom was £34,000 per mile, and this is the lowest amount returned. Since then it has increased year by year, until in 1893, it reached £47,000 per mile, and the contracts for the extension of the Manchester, Sheffield, and Lincolnshire railway from Nottingham to Quainton Road, to give access to London, show that this will cost at least £65,000 per mile for construction alone.

The cost per mile of making railways throughout the world varies but little from year to year—

	Per Mile. £
In 1840 it averaged	15,800
„ 1860 „	16,300
„ 1880 „	17,200
„ 1892 „	15,500

The latest return being the lowest, whilst in our country it stands at 38 per cent. above the lowest.

We as a nation were the first to supplement our advantages in cheap transport coastwise by constructing inland waterways, and we were also the first to utilize railways extensively. By these methods we undoubtedly gained a great advantage for our merchants and manufacturers, and added to the prosperity of the nation in times gone by. Now, however, we labour under the disadvantage of having to pay far higher rates for the carriage of our internal traffic than any of our competitors for the trade of the world. It therefore behoves us to see what can be done to alter a condition of things which bodes ill for our continued prosperity.

As we have seen the cheapest railway carriage is provided in the United States of America, where the average rate is 0·40d. per ton per mile, but in the same country the cost of carriage by water is said to be 0·20d., or one-half the cost of carriage by railway. The Americans are not content with this, but are annually spending large sums to improve their canals and rivers. To mention the most important of many in hand and in contemplation, a canal 36 miles long is being made through

Chicago, which will connect the waters of Lake Michigan with the river Missouri. Its primary object is for drainage purposes, but it is 160 feet and upwards in width, and will be made ultimately 22 feet deep. This canal will allow of the passage of vessels from the Great Lakes and their tributaries, some 15,000 miles in extent, to the waterways connected with the river Mississippi and its tributaries, 16,000 miles in length, and form a vast system of internal water-transit such as the world has never seen before. All these waterways will be toll-free. The Americans are, the writer believes, our most formidable rivals in the future for the trade of the world, and they inherit much of our energy and capacity for business. They raised in 1893, 162,800,000 tons of coal, as compared with 164,300,000 tons raised in the United Kingdom in the same year, which was, however, the year of the great coal strike. The coal output in the United States of America in 1889 was 126,000,000 tons, showing an increase of 36,800,000 tons, or 29 per cent. in four years.

The largest coal output returned for this country was in 1892, viz., 181,800,000 tons, and showed an increase in four years of only 7 per cent. The Americans claim that with a population of 65,000,000 the United States of America produce and consume over one-third of the iron, cotton, and copper, and consume one-fourth of the wool and sugar produced throughout the world.

If it were not that the distances which separate the products of the country are so great, the writer would fear for our position. We have at any rate no points to lose, and unless we make use of our inland navigations as a supplement to our coasting and over-sea trade we shall be neglecting a golden opportunity.

Railway rates have been decreasing in the United States of America for a number of years. In the case of seven trunk lines, including the New York Central, the Erie, etc., railways, the average freight rate per ton-mile fell from 1·4d. in 1865 to 0·32d. per ton in 1890, whilst the average net incomes increased on these trunk roads from 4·04 per cent. in 1865 to 6·39 per cent. in 1890. In spite of the reductions above-mentioned, the average value of the stocks of these seven great railway companies was virtually the same at the two periods. These roads are parallel to or in continuation of the line of navigations through the Great Lakes, and were competing with the most commodious water-route in the country. The great reductions in rates were usually commenced on these railways and spread to other parts of the United States of America. In fact, industries flourished, and rendered low freights beneficial to carrier as well as to producer and consumer.

The impossibility of regulating railway rates by law has lately been proved in America, where the Inter-State Commission appointed for this purpose has failed. In this country we have had little or no reductions in transport charges by railways, during the last forty years, and after ten years of agitation and an enormous expenditure of time and money, it is questionable whether even now any appreciable reduction has been obtained. These charges, it should be remembered, were first levied when the value of money was relatively much higher than it is now.

The following is an extract from an address on the subject of "Freight Rates" by Mr. E. R. Johnson, Instructor in Political and Social Science, Haverford College:—

> The cheapest freight rates by rail to be found in the world are those for grain between Chicago and New York. And why? Because the cheapest inland water-transportation rates in the world are those between the same points.
>
> All the railroads of the United States have been steadily lowering freight charges during the past twenty years, and largely, of course, because improvements in track and equipment have made this possible. Those roads, however, that have made the most improvements and the greatest reductions in rates are the great trunk-lines leading into New York from the west—those that compete with the Great Lakes, the Erie canal and the Hudson river. The average freight earnings per ton-mile of all the railroads of the United States for the year ending June 30th, 1890, were 0·941 cent. For the year ending June 30th, 1891, they were 0·895 cent. The ton-mile earnings of the New York Central and Hudson River railroad were 0·730 cent, and on the Pennsylvania railroad 0·661 cent; on the Lake Shore and Michigan Southern 0·653 cent; and on the Michigan Central 0·726 cent; whereas the average earnings per ton-mile on the Chicago, Milwaukee, and St. Paul, and on the Chicago and North-western roads coming but slightly into competition with the Great Lakes and other waterways were 1·06 and 1·03 cents respectively. The following table, showing the wheat rates per bushel from Chicago to New York for the years 1868, 1880, and 1891, by water, by water and rail combined, and by rail, indicates very plainly how freight rates have fallen, and how this movement has been led by the waterways:—

	By Lake and Canal. Cents.	By Lake and Rail. Cents.	By Rail. Cents.
1868	22·79	29·0	42·6
1870*	17·10	22·0	33·3
1880	12·27	15·7	19·9
1889*	6·89	8·7	15·0
1891	5·96	8·53	15·0

> The important influence of the Erie Canal on freight rates has often been emphasized.

In Belgium, railways are owned by the State, and the tolls are fixed so as to provide the cost of working, maintenance, and bare interest on the capital cost; so little margin, indeed, is allowed that some years ago the passenger fares had to be raised to prevent the State from being an absolute loser. The lowest remunerative charge for working is stated by the Minister of Public Works to be 0·483d. per ton per mile.

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* The figures for 1870 and 1889 are in addition to those given by Mr. Johnson.

In France, the charge under very similar conditions is put at 0·592d. per ton per mile, and is made up as follows:—

Locomotive power ...	...	...	... 0·140d. per ton per mile.
Rolling stock ...	...	...	... 0·078d. „ „
Wages and maintenance ...	...	...	... 0·078d. „ „
Interest and general charges	...	...	... 0·296d. „ „

Sir Geo. Findlay, the late general manager of the London and North-Western Railway Company, stated that the cost of working full train-loads of coal and returning empties between Wigan and London was 0·21d. in 1870, and had risen to 0·24d. per ton per mile in 1875.

These results, together with the charge of 0·4d. per ton per mile already quoted as the cost by American railways, appear to give good ground for taking 0·5d. or ½d. per ton per mile, as the lowest possible rate of carriage for general goods traffic by railway in this country, if a moderate return is to be paid to the shareholders. The freight-rate for coal on the Taff Vale railway in owners' trucks for a full train-load and for one consignee was given as 0·55d. per ton-mile in 1889, the statutory charge for waggon hire being 0·125d. per ton-mile.

Mr. Gobert, who has studied this subject, puts the cost by canal on annnal traffic of 600,000 tons per mile in Belgium as 0·284d. per ton per mile made up as follows:—

		D.
Tolls	Interest and redemption of capital	0·112
	Repairs and maintenance	0·022
Freight	Towing by steam	0·047
	Boat and boatmen	0·103
		0·284

This is a trifle above the cost of the through coal trains, for working only, as given by Sir George Findlay.

The 4 per cent. is taken on a capital cost of £11,500 per mile. Mr. Dufourny states that the rate of freight from Liége to Antwerp is from 1s. 9½d. to 1s. 11d. per ton on a navigation 97 miles long and 7 feet deep, or less than 0·25d. per ton per mile, and that in spite of two competing lines of railway, the traffic amounts to 570,000 tons per annum.

Upwards of 6,000,000 tons of goods are carried into Paris by water annually. This traffic is 41 per cent. of the total entering the city by railway and water; 1,000,000 tons is carried from Rouen in direct competition with a railway.

Berlin is supplied to the extent of one-half of its imports by canal.

Of late years the percentage carried by water has increased in much greater proportion than by railway in both France and Germany.

Of the traffic carried by rail and water in the United States, 27½ per cent. is water-borne, notwithstanding the cheap railway rates that rule in that country; in France it is 30 per cent.; and in Germany 23 per cent.; whereas in the United Kingdom it is less than 11 per cent., and this value is too high owing to the goods being returned over and over again by different canal companies.

If our competitors are economically right, we must be economically wrong in not using inland waterways to a much greater extent for the purpose of transport.

The capacity of canals for traffic may be partly gauged by taking the figures in the return for 1888 wherein we find that with a length of 159 miles the Birmingham canals are credited with a traffic of 7,713,000 tons, or 48,500 tons per mile, but as portions of the system are congested with traffic while other portions are much less used, it is clear that on certain lengths the tonnage bears no comparison to this amount. On the Birmingham and Warwick Junction, a canal for narrow boats only 2 miles 5 furlongs long, having six single locks, the return shows the traffic for the year to be 194,680 tons or 77,900 tons per mile.

The Weaver navigation return gives 1,500,000 tons on 20 miles of waterway, or 75,000 tons per mile. Nearly 1,000,000 tons of this traversed practically the whole system, and over the lowest portion the ton-mileage must have been at least 1,300,000 tons per mile. The lower portion of the Aire and Calder navigation carried a still greater ton-mileage over a single-lock system, and the Bridgewater, a barge-canal, passes 1,300,000 tons over a portion of its length.

On the Aire and Calder navigation, coal is conveyed in floating-tanks made up in long trains and hauled by a tug. The cost, including returned empties, was given before the Committee on Canals in 1883 as 0·0087d. per ton per mile, the journey loaded costing 0·0084d. This system has been continued, the plant for dealing with coal doubled, and the shipment of coal from Goole has increased enormously of late years. It was farther shown that on a movement of 4,000,000 tons of merchandize by cargo-carrying tugs, the cost was 0·03d. per ton per mile. Horse-haulage on the same route cost 0·14d. per ton per mile, nearly five times as much, and that, on the smaller section of the Leeds and Liverpool canal, on which boats are taken from the Aire and Calder, horse-haulage cost 0·33d. per ton per mile, ten times as much as steam-haulage, and more than double as much as horse-haulage on the larger canal.

The Weaver navigation has a larger sectional area than the Aire and Calder, and the haulage by hired horse cost 0·05d. for the double-journey (laden down and light up the river), as compared with 0·14d. per ton per mile on the Aire and Calder. Horses have to a large extent given place to steam on the Weaver, no doubt for reasons of economy as well as for speed and regularity of service.

If we regard the question of haulage in comparison with that of tolls charged, in fierce competition with railways, we see the preponderating importance of haulage.

The through rate of toll for bricks from the Midlands to London has been agreed at 2s. 6d. per ton, including 14 miles on the Birmingham canal. It is 135 miles from Birmingham to Brentford on the Thames, making a distance by canal of 149 miles.

	£	s.	d.
Taking 24 tons as a boat-load, the toll on 24 tons at 2s. 6d. amounts to	3	0	0
Haulage and navigation cost 0·33d. per ton per mile for 149 miles	4	19	4
Total cost of horse-haulage	£7	19	4

If the haulage be taken at the rate of steam-haulage ruling on the Aire and Calder twelve years ago, the account would stand as follows:—

	£	s.	d.
Toll	3	0	0
Haulage-cost, 0·03d. per ton per mile for 149 miles	0	8	9
Total cost of steam-haulage	£3	8	9

A difference of £4 10s. 7d. per trip. From this amount must be deducted the wages paid to the boatmen (the rate per ton varying with the capacity of the vessel), and the net saving would allow for an increase in toll, and leave a handsome profit under present conditions, but seeing that the cargo would be carried over five canals, if these were amalgamated a still better result would be obtained. A toll of 2s. 6d. per ton for 149 miles is at the rate of 0·201d. per ton per mile. Of this sum, the Birmingham canal claims 4d. as a minimum, 50 per cent. more than its fair mileage-proportion for 14 miles, beyond which distance an increase of toll is levied, while the Oxford canal takes 3d., or three times its due mileage-proportion, notwithstanding the fact that there is no lock on this length of the canal. It is singular, that the ordinary powers given by Parliament in the Acts of last year, viz., 0·5d. per ton for the first 10 miles, 0·45d. per ton for the next 10 miles, 0·25d. for the third 10 miles, and 0·15d. for the remaining distance owned by one canal company, would, if the 149 miles were in one canal work out to 0·201d. per ton per mile. The Oxford is an independent canal company, paying a dividend of 7 per cent. We have been accustomed to hear of the hard measure dealt out to canal traffic on railway-owned canals, but we have here an example of an independent company levying an exorbitant proportion, viz., $\frac{1}{10}$th of the toll for $\frac{1}{30}$th of the mileage. The above figures deal with tolls and the haulage of a loaded boat, apart from handling, terminals, cost of boat, and other charges.

Since 1882, economies have been effected in the use of steam, and it is necessary that many of our waterways should be improved so as to render its use more advantageous to the carrier. Canals with few exceptions, remain what they were before the introduction of the locomotive and are still worked by horses. The locomotives first used on the Liverpool and Manchester railway weighed about 4 tons and ran on iron rails weighing 35 lbs. per yard, drawing light trains. Now we have locomotives of 50 tons, steel rails of 90 lbs. per yard, and locomotive and train weigh upwards of 400 tons. In America, locomotives of 70 tons are now in use.

It is only necessary to compare the efforts made (with such signal success) to develop the carrying capacity of railways, with the neglect accorded to canal traffic, to see one great reason for the advance of the railway and the decay of the canal.

The advantage of large canals is shown by reference to the size of boats lately built in France. Between 1887 and 1891, the number of barges 126 feet long, suitable for passing the locks of canals of the first class, increased from 933 to 2,016, or 216 per cent. At the latter period 7,500 barges were capable of carrying 200 tons and upwards, and this number was nearly one-half of the craft employed on internal waterways.

The best design for barges of all sorts, and the best material of which to construct them, is a question well worthy of consideration, and if some gentlemen present would favour the meeting with an account of their experience, the information would be most serviceable, for we have no authoritative guide to refer to, and every owner is left to follow his own fancy.

Nearly all craft using canals are built of wood, but by degrees metal is being employed. Narrow canal-boats are confined to inland waterways almost entirely; they, however, navigate the estuary of the Thames as low as the London docks ; they do not venture on the wider and more stormy estuary of the Mersey. The barges using the second and third class canals navigate estuaries, and in many cases are provided with masts and sails, enabling them to proceed coastwise, the larger ones often conveying cargo for a considerable distance. Steamers which can be accommodated on the Weaver and Severn now ply regularly between London and Paris, as well as towns situated on canals in Belgium.

Messrs. W. Cory & Son, of London, coal merchants on a large scale, made an experiment last autumn in building eight sea-going barges. They are of steel, 125 feet long, 21 feet beam, draught loaded 8 feet. When light they stand 13 feet 6 inches above the water. Each barge carries 350 tons of coal. They are battened down and towed by steamer. Since last September, coal has been carried in these barges from the east coast, more especially the Humber-ports, to London; and when certain alterations about to be made to bridges on the Aire and Calder are completed, the barges can be loaded at the stages belonging to six of the West Yorkshire collieries, and thus the damage done to the coal by transhipment will be avoided, as well as the expense attending that operation. During one of the most severe of the recent gales, six of these craft were at sea and safely weathered the storm. The owners, moreover, are quite satisfied with the result of their experiment after four months' trial at the worst season of the year, and if coal can be carried in this manner, similar barges will, no doubt, be used for the carriage of other commodities, and the creation of this traffic adds another to the many reasons for improving canals.

From experiments recently made in France, it would appear that much greater importance attaches to the build of boats and the material of which they are constructed than is generally supposed. It is stated that a large reduction in resistance was gained when the sides of a wooden barge were covered with oilcloth. The barge was, the writer understands, towed at a speed of only $2\frac{1}{4}$ miles per hour. The spoon-shaped bow is also said to offer the least resistance to the passage of the boat through the water, while diminishing the carrying capacity of the boat to a smaller extent than a sharp bow.

If we refer to the Returns to the Board of Trade, 1890, we see that the Aire and Calder and the Weaver navigations, which, by improvement have been kept abreast of the age and are together only 113 miles long, carry 3,750,000 tons per annum, out of a total of 34,325,000 tons transported on our canals, or approximately $\frac{1}{9}$th of the total tonnage is carried on $\frac{1}{27}$th of the total length. On the other hand, independent canal companies are credited with a length of 2,025 miles, and a tonnage of 27,715,000 tons, or 13,700 tons per mile, while railway-owned canals with a length of 1,024 miles, carry 6,609,000 tons, or 6,500 tons per mile, less than half the tonnage per mile carried on the independent canals. These figures point to the necessity of freeing canals from railway control, and afford an example of the amount of traffic that can be worked on efficient waterways in keen competition with railways.

Abroad, the tendency is for long-distance traffic to be taken by water rather than by rail, which is, apparently, the reverse of what obtains in this country. Minerals and heavy goods provide the bulk of the traffic by water abroad ; but on many of our smaller canals, at any rate, this is not the case. The coal traffic by water to London is a bagatelle compared with the traffic by rail, whereas the coal and fuel brought from Belgium and the north-east of France to Paris is the heaviest traffic on the canals of that country, and over a portion of the river Seine below Paris amounts to upwards of 1,500,000 tons per annum.

The larger the cargo the greater is the economy in transit, as proved by the increasing size of modern ships and the demand for deep-water docks and harbours. Especially is this true of cargoes carried by canal where two boatmen can manage a barge of 300 tons, when an efficient waterway, that is one with ample sectional area, is provided. The saving in traction is also very great indeed. When steam-tugs were introduced on the Bridgewater canal, three laden barges were towed in train, but as the sectional area of the canal was improved, a fourth was added, and for many years the usual train has been four barges, each carrying a heavier cargo than at first.

The ordinary load for one horse is one barge carrying 60 tons, or two narrow canal-boats carrying 50 tons. The hauling of more than two is discouraged, owing to the length of time occupied in passing the numerous bridges. On a narrow canal, each boat would require a horse.

On the Weaver navigation, a single horse hauls a cargo of 100 tons, and 250 to 300 tons only requires two horses. The large barges on the Continent, carrying 300 tons of cargo, are hauled by two horses. The economy does not stop with this saving in haulage, as the narrow canal-boat costs upwards of £6 per ton of cargo to build, and a Weaver barge, carrying 260 tons, only costs about £4 per ton.

Economy of transport by water is assisted by the lessened cost of plant. A railway-train loaded with 220 tons costs for the locomotive and trucks £3,360. A steam-barge to carry the same quantity will cost £1,600; but this barge can be and is frequently employed to tow three other barges of 260 tons capacity, costing £1,000 each, and this not merely in the still waters of the Weaver and the Manchester ship canal, but across the estuary to Liverpool.

We thus find 1,000 tons carried by one steamer of 220 tons, costing £1,600, and three barges, of 260 tons (£1,000 each), costing £3,000, or £4,600 in all; whereas the cost of the railway-plant, for the same tonnage, would amount to £15,000.

The primary necessity is to free canals from railway control, and promote amalgamation of the various companies. Parliament recognized this view when it adopted the report of the Joint Committee of the two houses appointed in 1872, who stated *inter alia:*—

> The most important method by which the railways have defeated the competition of canals has been the purchase of important links in the system of navigation and the discouragement of through traffic.
>
> That no inland navigation now in the hands of a public trust shall be transferred to or placed under the control of a railway company, and that if the trustees of an inland navigation or of a canal apply to Parliament for power to purchase compulsorily a canal from a railway company, such purchase shall be favourably regarded by Parliament.
>
> That the utmost facilities shall be given for the amalgamation of adjoining canals with one another or with adjoining inland navigations.
>
> That no canal shall be transferred to or placed directly or indirectly under the control of any railway company, nor shall any temporary lease of any canal to a railway company be renewed, until it has been conclusively ascertained that the canal cannot be amalgamated with or worked by adjacent canals, or by a trust owning an adjacent inland navigation.

The amalgamation of existing canal companies is very necessary. The London and North-Western Railway Company is made up of forty to fifty different companies, and extends its connexions to Scotland and across the sea to Ireland. The two canal companies having the greatest mileage at the date of the Board of Trade return were the Shropshire Union, with 200 miles, and the Birmingham, with 159 miles, both of which are controlled by the London and North-Western Railway Company. Next in length was the Grand Junction, an independent canal company, with an aggregate length of 140½ miles. This company has lately purchased the Grand Union and the Leicestershire and Northamptonshire Union canals, and increased its length by 48½ miles, making a total of 189 miles under one management. The canal commences at Brentford on the river Thames, and is connected by a branch to Paddington with the Regents canal. Hitherto it has terminated by junctions with other navigations without reaching a large town. Now, however, it extends northward to Leicester, and will, let us hope, continue its policy of amalgamation until it joins hands with the Trent navigation at Nottingham, and in a westerly direction acquires the canals intervening between Braunston and Birmingham.

From the river Thames to Birmingham is 135 miles. Of this length 93 miles is Grand Junction proper, having barge-locks. The remaining 42 miles is over three companies' canals, 5 miles owned by the Oxford Canal Company, 14½ miles by the Warwick and Napton, and the remaining 22½ miles by the Warwick and Birmingham Canal

Company. These three canals are unfortunately narrow, and limit the through cargo between London and Birmingham to about 24 tons.

These facts lead up to the question of the necessity for improving canals. The utter disregard for uniformity in dimensions has been a great hindrance to their usefulness and prosperity. Uniformity of gauge was soon found to be necessary for railways, and has been achieved in spite of the great expense entailed in making the change. The canals, with few exceptions, remain as they were first made, differing in length and width of locks and in depth and width of waterway.

In France, a law was passed in 1879 enacting that all canals of the first class should be made for craft carrying 300 tons. This law requires the locks to be 131 feet long, 17 feet wide, 6½ feet deep over the sills, and that all over-bridges should have a headway of 12 feet. At that time there were 912 miles of canals and navigations which came up to the required standard out of a total of 7,300 miles. In 1892 there were 2,509 miles. This increase was attained by the addition of 390 miles of new and the improvement of 1,207 miles of old canals. The result has been that, whereas in 1876 the traffic amounted to 1,221,000,000 tons per mile, in 1891 it had increased to 2,211,000,000 tons per mile, an addition of 81 per cent. over the whole of France, but if the comparison be confined to the improved canals the addition amounts to 109 per cent. The increase in the average length of journey between 1881 and 1892 has been from 69 miles in 1881 to 192 miles in 1892, and the number of boats of the new type increased 54 per cent. between 1887 and 1891. The length of canal or navigation carrying the heaviest traffic connects the coal-fields of the North of France and Belgium with Paris. The length from the frontier is 177 miles. The tonnage carried on this line of canals in 1875, amounted to 283,875,000 tons per mile; in 1885, it amounted to 364,237,000 tons per mile; in 1891, it amounted to 453,197,000 tons per mile, an addition of 60 per cent. in sixteen years. In 1891, more than 21,000 boats passed through certain locks on the line of canals, having a total carrying-capacity of over 3,500,000 tons. Since 1881, considerable improvements have been carried out on these canals, enabling the cost of traction to be reduced, and with it the freight charges have been lowered by 15 to 20 per cent.

The canals of the first class which, as we have seen, are about 2,500 miles in length, are approximately one-third of the total length of the inland waterways, carry two-thirds of the tonnage shipped on the canals, and the work done on them amounts to four-fifths of the total ton-mileage traversing the French waterways. These figures show the immense superiority of an efficient canal. The traffic is seventeen times more active on the main lines of communication than on the secondary routes. In 1876, the ton-mileage carried on French canals amounted as we have seen to 1,221,000,000; in 1884, to 1,532,000,000, or an addition of 25 per cent. in eight years. In 1893, it was 2,256,000,000 tons per mile, an addition of 47 per cent. in nine years following; while in twenty years the traffic had doubled.

It is also found that the mean length of voyage is 91 miles by canal and 82 miles by railway, and that the St. Quentin canal over a portion of its length carries 4,456,000 tons, whereas the most heavily-worked railway line, which is between Avignon and Marseilles, carries only 2,787,000 tons per annum.

The growth of canal-traffic as compared with railway traffic is also worthy of consideration, for the tonnage per mile carried, divided by the total length of the two systems, shows that the use of canals per mile is now 84 per cent. of the user of the railways, whereas in 1882 it was only 41 per cent.

Figs. 1 and 2 show in tons per kilometre (a kilometre being approximately ⅝ mile) the quantity of goods and minerals moved during each year from 1847 to 1891 by water and rail. It will be seen that starting from a few thousands of tons in 1847, the French railway tonnage had overtaken the canal tonnage in ten years, and has increased very materially since then, but from about 1880 the comparative increase has been at a diminishing ratio.

In 1882, the total length of railway lines in France was 16,044 miles, and of canals 7,644 miles. The total weight per mile carried on the railways amounted to 6,865,500 tons and on canals to 1,415,000 tons, or 20 per cent.; in 1892, the length of railway lines was 21,800 miles, an increase of 5,755 miles; whereas the length of canals was 7,747 miles, an increase of only 122 miles. During this period the railway-carriage increased to 7,575,000 ton-miles, the canal-carriage to 2,255,625 ton-miles—that is, the canals did 30 per cent. of the carrying work in the latter period as against 20 per cent., in the former, although their length had remained practically unaltered.

Having passed in review some of the principal circumstances attending the use and development of canals, and having noticed the neglect with which that important mode of transport has been regarded in this country, and the different treatment that it has received from the most opulent and civilized of foreign nations, who are also our chief competitors in trade, it remains to consider whether we should rest content with things as they are, or seek for a means of reviving canal traffic.

FIG. 1.—WATERWAYS.—TONS PER KILOMETRE.

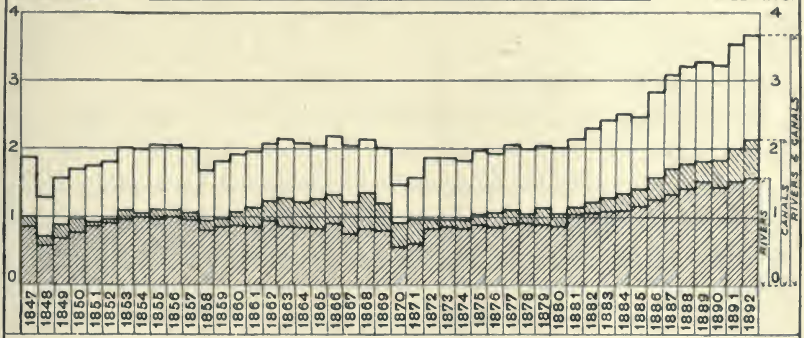
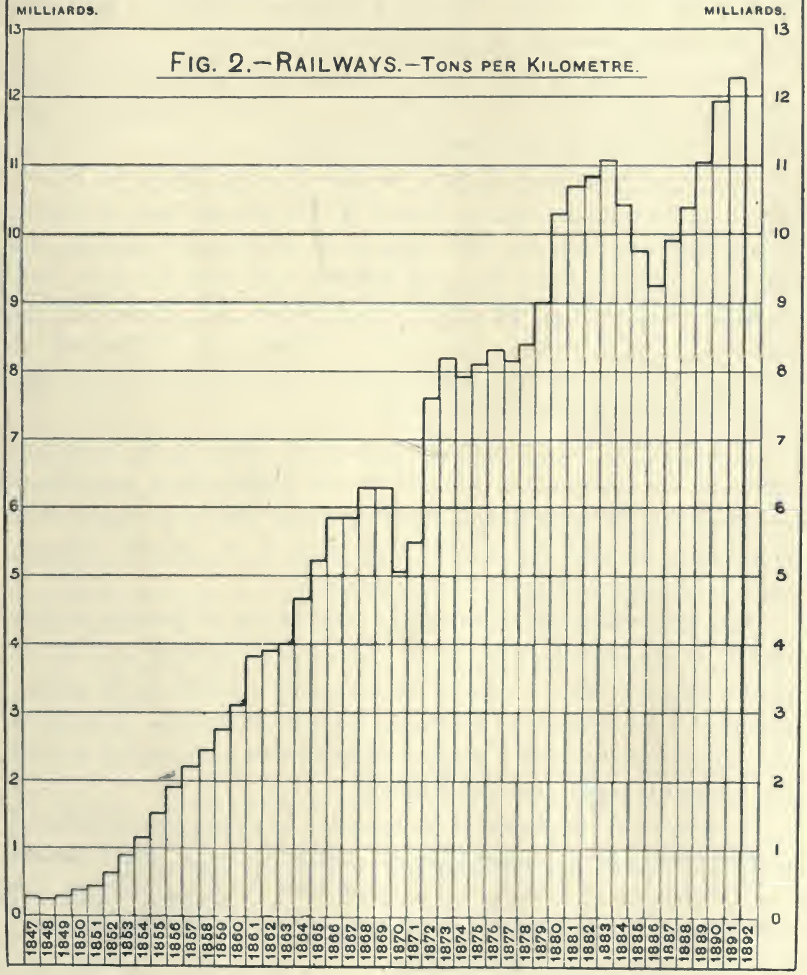


FIG. 2.—RAILWAYS.—TONS PER KILOMETRE.



It is shown that the transport of goods within the kingdom is far greater in quantity than the external transport, that railway rates are higher than elsewhere, and that there is no hope of a general reduction in railway rates being obtained.

On the other hand, Parliament has recognized that railways ought not to own canals, and has given effect to this opinion by passing the Act of 1889, which compelled the Manchester, Sheffield, and Lincolnshire Railway Company to sell the canals between Sheffield and the Trent to an independent canal company to be created after the passing of the Act. The Report of 1872, previously referred to, also recommends the amalgamation of existing canal companies, and we have seen that this has been acted upon by the Grand Junction Company which has obtained an additional 48½ miles of waterway for the small sum of £17,000.

So far, these are the chief results that have followed the Report which emanated twenty-three years ago from a committee containing many eminent members of both Houses of Parliament.

The rate of progress is too slow, the reasons being, firstly, the Report was in advance of the opinion formed by the general body of traders who at that time took but little interest in the "canal" question, the conditions of trade being then very different from what they have been since and still remain. Secondly, the difficulties in carrying out the suggestions are very great ; and farther, without capital being secured for improving the waterways, their freedom and amalgamation would only half fulfil the needs of the community.

If a powerful railway company is to be at liberty to use to the full extent all the opportunities afforded by our Parliamentary proceedings for preventing the acquisition of a railway-owned canal by an independent proprietary, we need not wonder that there is no general response made to the invitation given by the committee.

It is very seldom that so powerful a combination of interests as that formed in Sheffield in 1889, can be induced to act together in a matter of this sort, and, after a delay of six years, only a portion of the capital, required for the purchase of the canals, has been subscribed. This leaves the railway company with a preponderating interest in the capital account and a majority on the board of directors.

It appears to the writer to be necessary to obtain an expression of opinion from trading communities and corporations that water-carriage must be treated as a matter of real importance to trade, and that this should be made with sufficient vehemence or urged with sufficient force to compel attention at Westminster.

The Association of the Chambers of Commerce of the United Kingdom have at five meetings, including that held at Huddersfield in 1894, passed resolutions advocating the compulsory purchase of canals by the Government. This is one solution of the difficulty, and appears to many thoughtful people to be the only satisfactory solution likely to be obtained.

The Government will never adopt a proposition of this sort without previous enquiry, and in the writer's opinion the best method of proceeding would be to obtain a Commission, very similar to "The Royal Commission on Public Works in Ireland," which was appointed in 1886, and on whose report the Light Railways (Ireland) Act was passed in 1889. The Commissioners were the late Sir James Allport, Mr. Abernethy, Mr. Wolfe Barry, and Mr. J. T. Pim. Their powers were drawn widely, and the result of their enquiry was a very valuable report on the public works of Ireland, and more particularly on the railways, which is well worth careful study. It has always appeared to the writer that railways in Ireland and canals in England had certain features in common.

The commissioners found that there were forty-one railway companies with a total of 2,991 miles, only 611 miles of which were double line, that fourteen companies had less than 100 miles of main line, and that the average was only 135 miles per company. Owing partly to this, they found the percentage of working expenses excessive, viz., 55 per cent. of gross receipts, compared with 53 in England and 50 per cent. in Scotland. They advised amalgamation, and estimated that a saving would be effected of £40,000 per annum in working expenses and £55,000 in management, making a total of £95,000, equal to 6½ per cent. of the net receipts of all the railways.

The reference to an English Commission on canals should be widely drawn, and include the consideration of purchase by the Government, as well as the provision of simple but equitable means for the transfer of canals from railways to independent companies, and for the amalgamation of canal companies among themselves, with a proviso for exercising compulsion under certain conditions if it were found necessary. The provision of funds for the improvement of canals might be made on the lines of the Bill of 1861, "To facilitate the construction and improvement of harbours" by authorizing loans to harbour authorities by the Public Works Loan Commissioners, who are empowered to lend money at 3¾ per cent. for the purposes of the Act. In consideration of the reduced value of money, the rate of interest might now be fixed at 3 per cent.

Without more minute information as to the amount of traffic that is carried from place to place by railway and canal, it is impossible to dogmatize on the question of improvements. All canals should be compelled to allow steam to be used. To quote a very apt phrase used by the *Times*, "if one were obliged to condense the history of the nineteenth century into a single word, that word would be steam," and yet on the majority of the canals at the end of this century, steam is never seen, and on many it is prohibited, unless the sanction of the Board of Trade is obtained, and this may involve in many cases an additional toll. Surely that fact alone is an indication of the parlous state of the canals in this country. Uniformity of gauge must also be aimed at. It is a fortunate circumstance that the locks for considerably more than two-thirds of the total mileage are wide enough for barges of the width of the standard French barge. Locks to accommodate trains of four barges of the present type would be a *sine quâ non* on an improved canal.

It would be useless to expend money on improvements except on main routes, and the first to be taken in hand should be the line from London through Birmingham to the Mersey, which would link the trade of the Thames and the capital of the country with the thickly populated Midlands, and the Midlands with the ports of Liverpool and Manchester.

The improvement of canals is a question of more immediate importance to the inhabitants of Birmingham and district than to any other community. They occupy a central position, and are now compelled to import raw material in large quantities from the coast and require cheap carriage both for exports and imports. The question is of scarcely less importance to the members of The Federated Institution of Mining Engineers, for undoubtedly on a canal system in harmony with the requirements of the trade of this country the bulk of the traffic would be in coal and other heavy minerals, requiring coal to reduce them to a manufactured state.

The writer hopes that, after discussion by the members, a resolution will be passed which will claim attention from the "powers that be," and lead to strenuous efforts being made to place the canal system in the condition of rendering good service to the trade of the country.

The resolution suggested for your consideration is as follows:—"That having regard to the urgent need for utilizing more fully the canals of this country, the President of the Board of Trade be asked to call for a return, giving particulars of canals, and the traffic thereon, for the year 1894, and be requested to receive a deputation from this Institution with a view to the appointment of a Royal Commission to consider the whole question of inland navigation; and that Members of Parliament be invited to join the deputation."

The following paper by Mr. J. A. Saner on "Canals" was taken as read:—

CANALS.

By J. A. SANER, Assoc. Mem. Inst. C.E.

Everyone is now quite aware that, unless the canals are greatly improved both in size and uniformity, they will never be able to occupy the important position, as means of communication, which they should and would do if properly and systematically arranged.

Although the author knows that many men of great experience contend that canals worked in conjunction with railways could not be made either to pay or to allow the railway to pay, he cannot but hold the view, if the canals were of sufficient size, and as uniform in gauge and capacity as the railways are, that they could be worked side by side to mutual advantage, largely doing away with the goods train, and saving the risk of accidents which now, unfortunately, are so often attributable to the shunting and other operations incidental to goods traffic. The canal would take the bulky and heavy traffic, such as coal, iron, heavy machinery, stone, etc., and the railway would take the passengers and other perishable and light articles, on the principle that, as the writer heard an engineer once say, "you do not carry a bale of cotton on a hansom cab, nor hire a lorry when you want to catch a train."

The writer proposes, therefore, to explain as briefly as possible his ideas as to the most suitable dimensions for an uniform system of canals in this country, and as to the method of working them; the ideas being based on his experience of the river Weaver, with which he is intimately acquainted, and on the other rivers and canals through which he has either passed or been brought in contact.

Of course, he is leaving out of consideration large ship-canals, such as the Suez, Manchester, or Gloucester canals, the conditions of which are only applicable in few instances, and scarcely come under the heading of inland navigations.

The chief disadvantages of canals are that—

(1) The rate of transit is comparatively slow as compared with railways.

(2) The liability of freezing in winter, and disorganization of traffic; and

(3) Generally the goods require lifting out of the boats, and therefore require special appliances for discharging.

On the other hand, canals have the advantages that—

(1) Goods can be carried in greater bulk.

(2) The boats can load and discharge at any point on the banks without the risk of collision or construction of sidings.

(3) For fragile, or partially fragile articles, such as bricks, pipes, light castings, etc., there is less liability to breakage; and

(4) The cost of carriage by water is less than the cost by rail.

The first and second disadvantages can now be overcome for all practical purposes—at any rate, during a normal English winter—by the use of steam or other power engines, instead of the manual and horsepower at present employed for hauling; but the use of steam necessitates a larger sectional area of waterway, and the thorough protection of the banks.

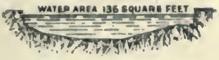
The slow progress on a canal is also largely due to the necessity of passing through a lock at each change of level, and although a railway train stops at numerous stations, it is possible to run the express trains for any required distance without stopping; whereas on canals, unless the traffic is confined to short lengths, the lock-delays are the same whether the traffic is so-called express or not. The chief considerations, therefore, to be taken into account in laying out a canal are that the changes of level may be as few as possible, without making the course too long and winding, and the provision of means for overcoming changes of level of considerably greater height than those now existing.

The third disadvantage is one which can be overcome by suitable machinery, and is almost equally applicable to railways, many articles requiring the use of a crane, whether they are being loaded or discharged from either a boat or a truck. The steam canal-boat has even an advantage in being able to carry a mast and derrick attached, for loading and discharging. Nearly all the Weaver boats are so fitted, and excellent results are obtained.

DIMENSIONS OF CANALS.

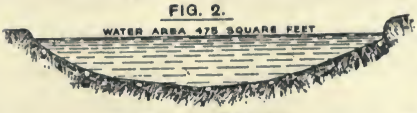
In constructing a canal, or canalizing a river for rapid transit, it is essential that the sectional area should be ample, it being well known that, within certain limits, the greater the ratio of the sectional area of the waterway to the sectional area of the boat, the less the resistance; this was very forcibly brought before the writer during a tour he made through some of the English waterways, when he found that in the Weaver, Severn, and Thames, his launch travelled easily 11 and 12 miles an hour, while on the narrow Trent and Mersey, Worcester and Stafford, and Oxford canals 4 to 5 miles was the extreme speed that she could attain.

FIG. 1.



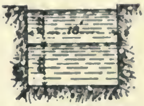
TRENT & MERSEY CANAL.

FIG. 2.



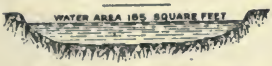
AIRE & CALDER CANAL.

FIG. 3.



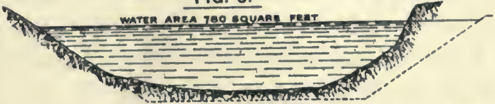
AIRE & CALDER LOCK.

FIG. 4.



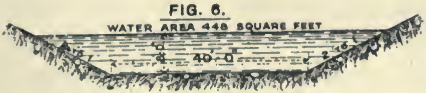
LEEDS & LIVERPOOL CANAL.

FIG. 5.



WEAVER CANAL.

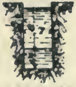
FIG. 6.



PROPOSED STANDARD CANAL.

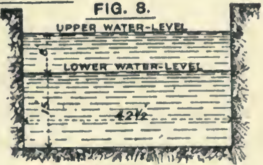
SCALE - 40 FEET TO 1 INCH.

FIG. 7.



ORDINARY
CANAL LOCK

FIG. 8.



WEAVER LOCK.

The Weaver has a depth of 11 to 12 feet and a sectional area of 780 square feet, while the canals have a depth of 3½ to 5½ feet and a sectional area of about 130 square feet. The ordinary traffic on the Weaver is carried in 250 to 300 tons barges and steamers, whose draught is 10 feet and beam 20 to 21 feet amidships; these vessels travel in the open lengths, when not towing, at a speed of 7 and 8 miles an hour, while on the canals the ordinary boats which do not carry more than 25 to 30 tons, with draughts of 2½ to 4 feet, are towed by horses at a rate of 5 to 6 miles an hour.

In France, where the question has been thoroughly investigated, the standard dimensions for a canal are: bottom width, 32½ feet; depth 6½ feet; and a sectional area of about 297 square feet. This standard canal would not be applicable in England on account of the size of the existing boats, and in 1893, in a paper read by the writer before the Liverpool Engineering Society, he advocated that the English standard canal should be: 40 feet bottom-width, 64 feet top-width, 8 feet depth of water, and 416 square feet of sectional area. Such a canal would accommodate vessels 75 feet long, 18 feet wide, 7 feet deep, and of about 210 tons displacement. It has been recently shown by Mr. Mars at the Sixth

International Congress on Canals, that there would be no difficulty in increasing the length of the boats, provided the locks and curves allowed it to be done, and provided the rudders were made of suitable size to give sufficient steering-power.

The new canals being constructed in Germany are: 46 feet in bottom-width, 76 feet in top-width, and 6½ feet deep, with 396·5 square feet of sectional area. These canals allow the passage of vessels 172 feet long 23 feet wide, and drawing 5¾ feet of water, which corresponds to a, carrying capacity of 400 tons. The writer sees no reason why the proportions of a narrow-boat, as they are now called, should not be followed in the larger sizes. These boats are 60 to 70 feet long by 6½ feet beam, or a ratio of length to breadth of about 10 to 1. If this ratio were adopted the carrying capacity of a canal of the given sectional area would be much increased, and each boat would be capable of carrying at least 300 tons of cargo.

Ger. canals recently constructed are of larger size

PROTECTION OF CANAL-BANKS.

The question of the protection of banks of canals may now be considered, and here there is a general concurrence of opinion that if rapid transit is to be achieved and steam or other mechanical power used, the only effective way is to pave the sides throughout, with either stone or concrete, for a considerable distance above and below water-level; and although it is not necessary where such protection is thoroughly done, it is an advantage to form a "berm" or shelf a few inches below water-level, upon which the force of the waves may be expended. This protection necessitates a wider strip of land being purchased, a cost which cannot be thought of where large towns or other circumstances make the land of great value. The writer's experience so far shows that the action of the water does not extend much below the trough of the wave formed by a steamer when she is keeping her course down the centre of the waterway, but it is often the case that vessels in passing or when drawn up for loading and discharging, work their propellers near the bank, and in such cases a hole is formed below the foundations of the wall. This action of the propellers is so powerful, that on the Weaver the writer has frequently removed a shoal by mooring tugs and working the engines against the mud or sand, with good results; so that, if absolute immunity from slips be desired, the foundation of the protecting-wall should be below the bottom of the canal. There is no doubt that a slope pitched with rough-dressed stone backed with "scabblings," and having a good batter is the most desirable form of wall. Many hundreds of feet of this description of work exist on the Weaver, built of red sandstone, more than fifty or sixty years ago, and it is seldom that any defect occurs except through undermining. Concrete would form a good protection, though if it were not made of considerable thickness the small settlements which always take place in newly-formed banks would cause it to crack and become very unsightly, repairs only adding to the disfigurement. Where stones are used any subsidences can easily be repaired.

The system largely used on the Weaver is to drive small wattling-piles, 6 to 8 feet long, and to fill the hole behind with broken stone, or bricks, or clinkers from the salt-works, placing a longitudinal plank so as to prevent the material from slipping through. These planks are bedded down as low as possible, and the slope is either paved with clinkers or soiled over. The clinkers are sometimes set in hydraulic mortar, and, if they are hard and well selected, will last for many years, although in many cases it has been found that the action of frost causes them to decay more rapidly than the mortar, leaving a honeycombed slope. In any case, clinkers are easily dredged out if they fall into the water and form no danger to traffic; they are also cheap, the cost of protecting the banks in this way varying from 1s. to 2s. 5d. per foot.

On a river like the Weaver, where it is not possible to draw down the water for repairs, the above-mentioned method acts very well; but in building a new canal, the writer would certainly recommend one of the more substantial forms of protection.

When the canal passes over an embankment or through very porous soil, it is necessary to case it with clay-puddle to prevent the water from oozing through, but this has seldom been found necessary in the case of the Weaver, where, although it is raised in several places considerably above its normal level, no puddle has been used. This is probably owing to the position of the river in its own valley; but on several occasions the writer dammed off the water with merely an embankment of sand, which acted admirably, showing that the percolation is not so great in that material as sometimes imagined, and points to the possibility of dispensing with clay-puddle in many cases. In these sand-dams it was, of course, vitally necessary not to allow the water to flow over the top, as immediately it did so, the whole embankment was washed away.

Where special wharves are required, they should be built with solid masonry or concrete walls, or where it is impossible to lower the water so as to obtain a suitable foundation, timber-piling may be used, which, if properly tied back with iron rods, will serve well as a wharf for from fifteen to thirty years, according to the quality of the timber and the strength of the work.

It is always advisable to use timber of ample dimensions, as the labour of driving is very little more, and it is very difficult to efficiently repair work of this nature without drawing the old piles and remaking the wharf, especially when heavy buildings are near the edge.

Another reason for abnormal strength is that the watermen will fasten their ropes to the piles however much they may be cautioned to the contrary, and however well the wharf may be provided with suitable mooring rings or posts. There is thus often a considerable strain, especially with large 200 to 300 tons crafts.

Locks, Etc.

The next important feature to be considered is the method of effecting the changes of level from one pound to another, and here there are still many opinions as to the means to be adopted, owing to the difficulty of dealing with the heavy weights to be provided for, and the necessity for economy in time, and in the use of the water in most canals. At present there are three methods of overcoming the difficulty which have been tried on a large scale:—

1. The ordinary lock which has been in use from time immemorial.
2. Inclined-planes or ship-railways, by which a large tank full of water, supported on wheels, is drawn up an inclined railroad, or the boat is drawn out of the water and carried in a cradle.
3. Hydraulic-elevators, in which the tank is supported and lifted vertically by means of hydraulic power actuating a single ram, similar to those at Anderton on the Weaver, Les Fontinettes in France, and La Louvière in Belgium.

As before mentioned, the fewer changes of level in a canal the greater is the speed with which it can be worked, and in undulating or hilly country the number of locks in the existing canals is so great that a large percentage of the total time taken to navigate from one point to another is occupied in locking through.

A very good example of these delays may be experienced by travelling along the canal from Worcester to King's Norton, where there are no less than 57 locks; and in 1891, when passing through in a steam launch, it took the writer ten hours and twenty-one minutes to travel 21 miles, or an average speed of 2 miles an hour, the total height to be overcome being 428 feet.

The features of a lock are so well known that they need not be described here, for a moderate fall (say 15 to 18 feet) it would be difficult to improve them, both as regards ease of working and cheapness of first cost; but when the fall exceeds these heights the commotion caused by the rush of water is liable to seriously endanger a small boat, and to cause a larger one to strike violently against the sides and gates. Numerous expedients have been suggested for overcoming this difficulty, and an arrangement was devised for the Panama canal-locks by which the orifices for filling and emptying were distributed over the bottom and sides in such a way as to break the force of the water. This design may succeed when everything is new and the lock is of large area. It would greatly increase the cost of the works, and in time the small passages would be liable to be partly blocked by the mud and detritus which is drawn into the culverts, and thus impede the flow of water. On the Manchester ship-canal and the Weaver, the culvert-openings are distributed along the side-walls, the size of the openings, however, being so large that nothing can possibly get stuck. Even then, with a fall of only 16 feet, which is the deepest, great care is necessary to prevent damage to small craft during the filling of the lock. The loss of water in deep locks is also excessive, especially when the traffic is all going one way, and though on a river like the Weaver it is very seldom that there is a scarcity of water, on artificial canals this is a great consideration, making it imperative in dry seasons to delay the boats until they can be alternately raised and lowered.

At the Fourth International Congress on Inland Navigation a design* was brought forward for a lock of 65 feet (20 metres) fall, in which the difficulties of commotion in the water, and excessive loss, were overcome by side chambers at different levels, which stored three-fifths of the total quantity. The lock, which was of the French standard size, was estimated to cost £36,000, and to pass a boat through in less than twenty minutes. Even in this case the loss of water at each operation was 26 feet (8 metres) in depth, and would seriously draw upon the supply in a summit pound.

INCLINED-PLANES.

The writer has not had any personal experience of inclined-planes, but would urge that the easy gradient required would frequently necessitate more land than was available, and the oscillation would cause the boats to strike against the sides of the troughs.

At the Fourth International Congress on Inland Navigation, a scheme was also submitted for an incline of 98 feet (30 metres) in height to carry the French standard boats; but the estimated cost was £60,000, which is very much greater than that of the lock with 65 feet (20 metres) fall and scarcely in proportion. The wear and tear of the parts would be considerable, and the chains or ropes connecting the two troughs would require constant overhauling and examining. The most extensive use of planes, that the writer knows of, is on the Oberland canal in Germany, where there are five in succession, with lifts varying from 45 to 80 feet. The boats are only of 60 to 70 tons burthen, with flat bottoms, and are not kept afloat, but rest on a grid for nearly their whole length. This system does not appear to be applicable for larger craft, as the weight of the cargo, especially if in bulk, would set up severe strains upon the sides of the boats when taken out of the water. The cost of these inclines averaged £5,140 each.*

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* *Report*, page 21.

Lifts.

The third way of solving the problem is by means of vertical hydraulic lifts. The first of these was built at Anderton in 1874-5, by the Weaver Trustees, acting under the advice of Mr. (now Sir) E. Leader Williams. This lift (which is described in detail by Mr. Sydenham Duer †) raises and lowers the canal-boats through a height of 50 feet between the river Weaver and the Trent and Mersey canal, being connected with the latter by a wrought-iron aqueduct. The boats are enclosed in a water-tight trough, and remain afloat during the whole operation. The same principle has since been adopted, as before mentioned, in France and Belgium for vessels of much larger dimensions.

The writer has now had ten years' experience of the working of the Anderton lift, and cannot speak too highly of its efficiency, although no doubt as it was the first of its kind, it has been possible to improve some of the details of construction in those more recently built.

The caissons or troughs are capable of holding two of the narrow boats in use on the canal, and the operation of entering, lowering, and opening the gates and passing out can be performed in from ten to twelve minutes. The waste of water is 6 inches deep over the area of the trough, eleven-twelfths of the stroke being performed by means of the weight of this water, and the remaining power being supplied by a small engine working an accumulator.

As the lift has two troughs which are in equilibrium until the 6 inches extra of water is put in, one always ascending, and the other descending, it is ready for either up or down traffic, and when vessels from both sides arrive at once it acts as a double lock.

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* *Foreign Office Report*, 1894, No. 345.

† *Proceedings of the Institution of Civil Engineers*, vol. xlv., page 107.

The objection raised to such lifts is their first cost and cost of maintenance, but when the number of locks which they replace is taken into account the difference of the former is not so very great, while the advantages to the traffic and the saving of time and water should fully compensate for the cost of the maintenance. The cost of the Anderton lift, with troughs 75 feet by 14½ feet, was £50,000; the cost of Les Fontinettes lift, with troughs 131 feet by 17 feet, was £60,000.

Supposing that in the first case five locks each of 10 feet fall had been built, they would have cost from £6,000 to £8,000 each, and the canal company would have raised insurmountable objections to the loss of water. The cost of maintenance chiefly consists in wages to the attendants. At Anderton, there are four labourers, one engine-driver, and one man in charge of the valves, which control the rams, he being also responsible for everything outside the engine-house, and stationed on the upper level, giving his orders to the driver by means of a speaking-tube. The total average cost of maintenance, including wages, coal, stores, and repairs averages £500 per annum, which amounts to about 1d. per ton on the traffic now using the lift.

It is, however, capable of carrying a very much larger number of boats than are passing at present, and if we allow four lifts an hour, with two boats each lift, carrying an average of 20 tons to each boat, and ten working hours per diem, the staff would remain the same, and the cost would only be 0·2d. per ton. Neither of these calculations takes into account any return traffic, which may be either light or laden, and would in a through route be in many cases the latter.

If the alternative system of five locks were adapted to modern requirements, with turbines for moving the gates and sluices, it would not be possible to allow any "bargee" or stranger to interfere with the machinery, so that at least three or four men would be required to be in constant attendance, and as the time taken to lock through would be equal to five times that required for the lift, the amount of tonnage would vary accordingly, and the capacity of the canal be lessened in a like manner.

It is, of course, questionable how long such a lift can be kept working in severe weather. The pipes and cylinders are, of course, either underground or properly protected against frost, but there is a certain danger that the icicles which form at the gates will prevent the joint from being properly made, and great care is necessary at such seasons. The writer has tried a steam jet to remove the ice at the joints, but with only partial success. However, during the writer's experience, the lift at Anderton has always been able to work until the canal was so full of ice that the traffic thereon had ceased.

The above facts certainly lead to the conclusion that for the canals of the future, with their steam and rapid traffic, lifts similar to those just described offer a feasible and economical solution of the problem of changes of level.

As before mentioned, the greatest drawback to the English canal-system has been the want of uniformity, and this is especially marked in the size of the locks. A glance at the Board of Trade return of 1888 will show that there are scarcely two canals with the same dimensions of locks, and that in no case is a through route available except for the smallest class of boats. In the paper read by the writer, before the Liverpool Engineering Society, he urged that a very good standard for locks or lifts would be 150 feet by 18 feet by 7 feet, and he did so for the following reasons :—

The standard lock adopted in France is 131 feet by 17 feet by 6½ feet; but in England this gauge would necessitate a fresh standard of boat, otherwise a large waste of water would take place each time any of the present boats used the locks. On perusing the same Board of Trade Return it will be found that 80 per cent. of the boats now in use could be economically passed through such a lock as the writer has suggested. The narrow boats would pass through four at a time and the "dukers" or "wiganners," or whatever local name they may be known by, would pass through two at a time, while if boats of proportionate dimensions to the narrow boats were built, they would be able to pass through one at a time with a cargo of 300 tons. It will probably be objected that hydraulic lifts could not be constructed of such dimensions, but those already in use in France are 131 feet long, and the possibility of constructing a tank of much larger dimensions than these, supported on a central-pivot, has been amply demonstrated on the Manchester ship-canal, where the movable portion of the Barton swing-aqueduct weighs no less than 1,600 tons and is 234 feet in length.

BRIDGES.

There is another form of annoyance and delay to canal traffic in the numerous opening-bridges, which exist in many places, and have to be worked by the boatmen. It is, of course, possible, under existing circumstances where the boatman is well in advance of his boat, to dispense with regular attendants, but with steam-traffic towing barges it is necessary to have attendants to open each bridge, as the delay of stopping and restarting would be insufferable. The only method of avoiding this annoyance and expense is to have fixed bridges, and as the boats using a standard canal would be able to lower their funnels, masts, and derricks these bridges need not have a greater headway than 16 or 17 feet, which would allow of light craft easily passing under. There would therefore be very few places where an opening-bridge would be necessary.

Artificial Lighting.

To make full use of a waterway the traffic should be able to work both night and day, otherwise it is seriously hampered in its competition with railways as regards speed.

It would be possible now by means of electricity to light a canal on the same system as a street in a town is lighted, but the cost of so doing would be enormous, and in the writer's opinion unnecessary on such a canal as he has been describing. On the Weaver, the traffic works night and day without any artificial lighting whatever, so much so that near the locks and bridges any lights in the lock huts or on the roads are carefully shielded, as the watermen complain, and justly so, that they are blinded by them. Unfortunately, the Anderton lift is only worked during the day time; had it been worked all night there would have been valuable experience as to the possibility of using these lifts without artificial lighting.

As it is now, however, there are frequently boats passed up and down in the early and late hours of the winter months without difficulty beyond extra carefulness.

The writer has often stood near the wheel of a river-steamer when running in the dark, or watched them passing from the shore, with a view to forming a judgment on this point, and as far as the open reaches of canal are concerned, he would certainly prefer to be without lights of any kind. As to deep cuttings, or the approach to locks or lifts, especially the latter, he is inclined to think that powerful lights, placed on high masts, and carefully shielded on the up-and-down stream sides, would prove an assistance rather than a detriment to the boatmen. On a canal where there was sufficient water, the power for these lights could be obtained by turbines, or in the case of lifts a small engine could be worked from the boilers.

Cost of Carriage.

The writer stated that a fourth advantage which canals had over railways was the cheaper rate of carriage, but having no personal connexion with railways, he had found it most difficult, not only to obtain reliable figures, but to form any tables from which averages might be taken. He had therefore been content with working out the cost of carriage by canals, for which he had ample data, and he thought that if the railway charges were no heavier than those he quoted, that they would hear very little complaint of their being exorbitant.

The writer has been obliged to choose some specific route for his calculations, and he has taken the proposed new canal from Birmingham to the Weaver as a basis.

They were all no doubt aware that for some time it has been proposed to construct such a canal to pass through Wolverhampton and the Potteries to Winsford on the river Weaver, which latter runs through the salt districts of Cheshire, and is connected to the Mersey and the Manchester ship-canal at Weston Point near Runcorn. That such a canal would not only be a great source of convenience and economy to the trader, but also a remunerative undertaking to the promoters, he had been convinced ever since he knew the districts concerned, and he only hoped that as soon as a reasonable opening occurs, the subject would be taken up by the inhabitants of Birmingham and Wolverhampton districts with all the energy which usually characterize their conduct of business.

Suppose, then, that this canal, which would probably be somewhat on the standard lines just laid down, is *un fait accompli*, and that the estimated cost has not been exceeded to any large extent.

The canal company might or might not act as their own carriers; in many cases it would pay the large trader to have his own craft, but whosoever owned the craft, the cost of working would be the same.

In these estimates the writer has not included any terminal charges or dock dues, which would be the same in any case, except when the trader was fortunate enough to have his works situated on the banks of the canal. To enable the canal to be fully utilized, the boats must be of the largest possible dimensions, and should work in trains of three or four at a time.

The writer has therefore taken a train of one steamer and three barges, with an average capacity of 250 tons each, and a total of 1,000 tons; this would be equal to 100 railway-trucks of 10 tons capacity, and forms a most convenient minimum for a train of vessels. Such a combination would be equal to the trains of craft now using the Weaver.

Statement showing estimated cost of conveyance by canal :—

First cost of plant for 1,000 tons—	
Steamer of 250 tons	£3,000
3 Barges of 250 tons each ...	4,500
Total cost	7,500

Cost of one voyage and return empty (if a return cargo were obtained some of these items would be lessened) on the basis of three trips per fortnight, each trip conveying 1,000 tons—

	£	s.	d.
Steam and bargees wages, including ton-money and other extras	20	19	4
Canal toll, 60 miles at ¾d. per ton per mile	187	10	0
Weaver toll, 20 miles at ¼d. per ton per mile	20	16	8
Upper Mersey dues, say	0	10	0
Total charges	229	16	0

The cost of 70 trips per annum conveying 70,000 tons would be—

				£	s.	d.
Cost of carriage				16,100	0	0
Maintenance, steamer, say	£150	0	0			
„ barges	90	0	0			
				240	0	0
Depreciation at 5 per cent				375	0	0
Interest on capital at 5 per cent				375	0	0
Total charges per annum				17,090	0	0

These charges would be equal to, say, 4s. 11d. per ton carried the whole distance, or 0·61d. per ton per mile.

If the canal had not the advantage of the rivers Weaver and Mersey the cost would be, omitting pence—

	£	s.	d.
Steamers and bargees wages, say	21	0	0
Canal toll, 98 miles at ¾d. per ton per mile	306	0	0
Total charges	327	0	0

The cost of 70 trips a year, carrying 70,000 tons would be—

	£	s.	d.
Cost of carriage	22,890	0	0
Maintenance	240	0	0
Depreciation at 5 per cent	375	0	0
Interest on capital at 5 per cent	375	0	0
Total charges per annum	23,880	0	0

These charges are equal to, say, 6s. 10d. per ton carried the entire distance, or say, 0·83d per ton per mile.

In taking ¾d. per ton per mile as the toll, a very high one has been taken, equal to the highest of the new rates chargeable on the Weaver.

In contrast to the above estimates the writer may venture to quote some figures taken from the present rate-book at Liverpool for railway-carriage between that city and Birmingham :—

	s.	d.	
Salt and coal			no rates in force.
Pig iron	8	0	per ton from station to station.
*Earthenware, in casks or crates	21	10	per ton, not carted at Liverpool.
„ in hampers	25	3	„ „ „
„ in boxes or cases	30	2	„ „ „
Woollen goods in bales, packages, or trusses	25	3	„ „ „
Machinery parts in cases, second class	21	10	„ „ „
Machinery not packed, third class, carrier's risk	25	3	„ „ „
Machinery not packed, at owner's risk	22	1	„ „ „

The question may be asked as to whether a canal between Birmingham and the Weaver, such as now referred to, would be a profitable undertaking to the promoters. Of this there can be little doubt, and to support this opinion, the writer has taken from the Board of Trade Returns for 1888 the following figures referring to existing canals. All named therein, with the exception of the Weaver and the Aire and Calder, are of the usual small size, so that it may be fairly argued that with improved accommodation and greater facilities the position would be at least as favourable.

Carriers.	Tons.	Net Revenue. £
Aire and Calder	2,210,692	112,796
Leeds and Liverpool	2,016,976	50,724
Bridgewater canals, now Manchester ship-canal	2,916,754	71,937
†Trent and Mersey	1,139,098	35,697
†Shropshire Union	1,124,598	4,473
Totals	9,408,118	275,627

or 7·03d. per ton carried.

Non-Carriers.	Tons.	Net Revenue. £
Birmingham canals	7,713,047	116,096
Regents canal	1,672,959	45,821
Stafford and Worcester canal	646,038	9,259
River Weaver	1,498,124	16,148
Totals	11,530,168	187,324

or 3·6d. per ton carried.

The gross totals of 20,938,286 tons and £462,951 show an average profit of 5·41d. per ton carried.

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* Earthenware is only conveyed at owner's risk unless properly protected by packing.

† Railway-owned.

Five of the above canals are carriers and four non-carriers, and any new company would also act as carriers, at any rate in part, if not entirely.

The average net revenue shown in the above tables amounts to 5·41d. per ton per annum, and as the least tonnage which may be expected between the different points *en route* between Birmingham and Liverpool may be taken at 3,000,000 tons, there would be a net profit of £67,625 after paying all working and other expenses.

By choosing what may be termed the Weaver-Mersey route, not only would the whole of the iron and coal country of Wolverhampton and Staffordshire and the Potteries be passed through, but there would be direct inland waterway connexion between the three large cities of Birmingham, Liverpool, and Manchester, and the existing docks and quays would be available without farther expenditure.

The writer does not wish it to be thought that in this paper he is advocating any particular scheme; all he wishes to impress is that we are many years behind our neighbours, Germany and France, in our canal system, and are therefore hampered in trade to an equivalent extent.

The connexion of Birmingham and the surrounding populous neighbourhood with the seaboard by an improved waterway would be a suitable enterprise with which to commence a new era for canals. The existence of the rivers Mersey and Weaver and the Manchester ship-canal point to the most practical route being along their already-prepared channels.

Lastly, the writer is of opinion that the dimensions both of waterway and vessels laid down in this paper are such as would be very suitable for a standard system of English canals.

Mr. W. H. HUNTER (Manchester ship-canal) considered that the revival of interest in, and the direction of attention to, the subject of inland navigation was one of the most hopeful of the economical developments of the present day, as it was, indeed, one of the most important. Without a really effective canal-system it was impossible to provide cheap carriage for either minerals or manufactured goods from the industrial districts of the country that lie at any distance from the seaboard, and without cheap carriage minerals must remain in their native strata, and manufactures must languish and ultimately perish. It was satisfactory to remark how the completion of the Manchester ship-canal, despite the formidable obstacles which were thrown in its way, and the recent rapid increase of the traffic borne upon its waters, had given a stimulus to the reviving interest in inland canals, one of its results being an application to Parliament during the current session for power to construct a new waterway to Oldham and to Royton in the county palatine of Lancaster. It was important at such a juncture as the present that every effort should be made to guide the public mind, not only so as to lead to public interest in canal development, but so as to render that interest intelligent and practical. It could not be doubted that The Federated Institution of Mining Engineers was doing good service in its day and generation in offering opportunity for discussion on the structural necessities, as well as on the economic considerations which should govern in the new era which had been, to all appearances, already reached. The first of the structural necessities was beyond question uniformity of type. It was essential, in a small and thickly-populated country like Great Britain, that an effort should be made to arrive at a standard minimum sectional area of lock, height of quay, radius of curve, etc., which should be adhered to in future operations, whether in the construction of new canals or in the improvement of existing navigations. In this, he (Mr. Hunter) was in cordial agreement with Mr. Saner, and with those who had preceded him in the same recommendation. From the conclusions arrived at by Mr. Saner as to standard sizes, he (Mr. Hunter) was, however, obliged to differ. In a standard type there could not be a greater error than that of putting the standard too low or making the type too small. Hence, even though it might be necessary from monetary considerations (although there was undoubtedly a time of rebound coming when money would be freely offered for public works and for the development of the material resources of the country) to spread the operations of the development and the modernization of the canal-system over a longer term of years, he (Mr. Hunter) would regret to see any standard adopted, or type of canal section, or lock accepted that would not provide for the free passage of a steam-barge or packet carrying at least 450 tons of deadweight, and competent to aid in the coasting traffic of this country. The standard that would ultimately be adopted would necessarily be the desirable modified by the practicable. The issues involved in the determination of this standard size were so great, and the interests concerned so important, that the Government should appoint a Royal Commission to enquire into, and submit recommendations upon, the subject as seen in the light of recent developments. Having regard to the diminution of resistance to the passage of a barge, the form of the cross section of the canal was of importance. For a single waterway, *i.e.*, that adapted for the passage of a single boat only, of any given size, it could be shown that the least possible resistance would arise when the area of the section was so distributed as to coincide as nearly as possible with the midship section of the boat, or, in other words, that the most advantageous section for a single waterway would be of a semi-elliptical form. It was, however, a primary necessity of an efficient navigation that two barges should be able to pass each other at any point of their journey; and a modification of the section must therefore be made by the introduction of a central parallelogram equal in breadth to the beam of the boat, *plus* due allowance for clearance. Farther, as it was in most cases impracticable to line the sides of the canal with rubble walls, a second modification was required, and slopes must be substituted for the curved sides of the ellipse. In forming these slopes it was desirable, with the view of obtaining the most efficient section with the least possible quantity of excavation, that the slopes should be made as steep as the nature of the strata would allow; and if this be done, and the bottom of the canal be dished in the manner suggested by the development of its section from the modified elliptical figure, it would be found that a maximum of efficiency could be obtained with a minimum of cost.

Mr. URQUHART A. FORBES wrote that he agreed with the opinion expressed by Mr. Wells as to the necessity for securing the freedom of canals from railway control and for promoting their amalgamation. He would, however, draw attention to the fact that the Railway and Canal Traffic Act, 1888 (Part III.), contained provisions which might, perhaps, be utilized for both these objects. (1) As regards railway control, section 38 empowered the Railway and Canal Commissioners to make orders for the alteration and adjustment of tolls, rates, and charges levied on the traffic of, or for the conveyance of merchandize on the canals controlled by railway companies, where it was proved to their satisfaction that such tolls, rates, or charges were calculated to divert the traffic from the canal to the railway, to the detriment of the canal or of persons sending traffic over the canal or other canals adjacent to it. And if the alterations required by the order were not made by the company within such time as it prescribed, the Commissioners might themselves make them. Section 42 also provided that in the event of the misapplication of a railway company's funds for the acquisition of any unauthorized interest in a canal, the canal interest purchased in contravention of its provisions should be forfeited to the Crown, the officers who permitted such application of the company's funds being made liable for their repayment to the company. (2) As regards amalgamation, he had already pointed out in his paper that section 44 provided for the establishment of a clearing system. In addition to this, section 37 extended the provisions of the Railway and Canal Traffic Act, 1854, as amended by the Regulations of Railways Act, 1873, which required companies to afford all reasonable facilities for forwarding traffic, to canals; while section 43 expressly empowered canal companies to enter into contracts for the arrangement of through tolls, and for the collection and recovery by any one of the companies on behalf of themselves and the other companies interested, of the tolls, rates, and charges payable in respect of such through traffic. Lastly, section 41, which provided for the inspection by officers, appointed by the Board of Trade, of canals which had fallen into such a condition as to be dangerous to the public or to cause serious hindrance to traffic, taken in conjunction with section 45, which provided for the abandonment of canals which had thus become derelict, seemed to offer facilities for their acquisition by companies or public bodies who could afford to turn them to good account. Clauses 3 and 4 of section 45 empower the Board of Trade to transfer such derelict canals to "any persons, body of persons, or local authority," and by means of a Provisional Order, "to provide for the constitution of a body to manage the canal or any part thereof, . . . and for any other matters which may appear to the Board of Trade to be necessary or proper for carrying this section into effect." The case of the Ouse, mentioned by Mr. Wells, which was inspected under section 41 in 1890, offers an illustration of this point. Under section 45, any of the numerous public bodies or companies concerned in the river, or any combination of them, might, presumably, apply to the Board of Trade for a Provisional Order, transferring the control of the navigation to them. The provision, therefore, seemed worthy the attention of those who are desirous of developing through water-routes.

Mr. J. A. SANER (Northwich) wrote that he had read with very much interest the papers upon canal and inland navigation. He would like to ask Mr. Wells whether he had ever compared his map of the inland navigations with that published by Mr. Priestley in 1831? He thought that the comparison would be interesting and instructive, for as far as he had had time to compare them, he did not find that there had been any extensive additions to the canal-system since 1831; but, on the other hand, there were many which were marked as being derelict on Mr. Well's plan.

Mr. EMERSON BAINBRIDGE (Sheffield) said that the comprehensive papers on canals would prove of great value to the members of The Federated Institution of Mining Engineers. He thought that Mr.

Wells had put the gist of the matter in his valuable paper when he said that "railway companies do not compete in rates." Colliery proprietors know well the value of this important statement, but he might mention that of the railway companies of this country, twenty-two of them in 1894 paid dividends amounting to £1,800,000 higher than the previous year. At the present time, the railway rates for coal from the Midlands were of higher value than the value of the coal at the pit. The Railway Rates Act passed in 1888, was a positive disadvantage to the trade of this country. It put the railway companies into one block, and naturally they fought for their own interests, and colliery owners had only an occasional opportunity of obtaining reduced rates. The various papers seemed to suggest that water-carriage would be reverted to. He was associated with the South Yorkshire canal, and had taken advantage of the recommendation of the committee, which met in 1872, referred to by Mr. Wells. The Sheffield Navigation Company had purchased the canal which goes from Sheffield to the sea. It had taken them twenty-two years to carry out the recommendations of the Parliamentary Committee which met in the year 1872. Mr. Wells mentioned the great advantage which lay in the width of a canal, and it would be very useful to know whether he would recommend that the extra width of the Weaver canal should be applied to all canals. He might also mention the relative speeds and costs of horse and of steam-haulage, as there was doubtless a very marked difference between the two. Mr. Wells had recorded some very interesting figures with regard to the growth of canal traffic in France, the user of canals at the present time being 84 per cent. as compared with 41 per cent. thirteen years ago. Probably instead of having a similar increase in England in favour of the canals, the ratio was much the same as thirteen years ago. On the general question of English trade, he thought that all would agree as to the desirability of cultivating foreign trade, and one of the great drawbacks was the rate for carriage in this country as compared with different parts of Europe and America. The difficulty of the Government acquiring the canals of the country was mentioned in the paper. One could imagine what an immense resistance would be exerted against it by the railway interest, but it was one of the remedies for the development of foreign trade against our own, and he trusted that one of the results of these papers would be to bring the question forward: namely, whether this mode of increasing English trade by acquiring the canals could be brought home to the present or some future Government.

Mr. M. H. MILLS (Chesterfield) said that there were very many practical difficulties in connexion with the use of canals. One was the question of transhipment: with a tender coal that was a very serious matter. There were not many collieries adjacent to canals; and it would not be a small matter to make a canal to every colliery. It would be better to consider what could be done to improve the railways before they thought seriously of spending large sums of money in making canals. Some collieries had been very successful owing to the facilities afforded by water-carriage. Perhaps Mr. Wells could afford some information on the subject of shipping coal into canal-boats.

Mr. Jeremiah Head (London) said that having recently been in the United States of America investigating railway matters, he was in a position to confirm what had been said about the very much cheaper rates at which freight-traffic was carried there than in this country. He had analysed several of the rates from the town of Birmingham, in Alabama, a great iron district, to different points of consumption to which they sent their traffic, and he found that they worked out generally from about 0·25d. to 0·20d. per ton per mile. The American manufacturers consequently had an enormous advantage as compared with manufacturers in this country, where, as might be seen from Mr. Wells' and other papers, the rates vary from 1d. to 1·4d. per ton per mile. It was a preposterous thing that companies which were created by Act of Parliament for the purpose of carrying goods and passengers by railways should ever have been allowed to acquire the waterways and the rights to carry traffic in any other way, and this legislative oversight had led to all the trouble. He did not think, however, that the remedy was to be found in the State purchase of all the canals. That would mean the placing of a large amount of national money into property of very doubtful value, and he was quite sure that the State had plenty to do in fulfilling its legislative and administrative functions without becoming the owner and manager of property of that sort. He agreed with the last speaker, who suggested that we should consider "what could be done to improve the railways." We might also consider why it required such a large amount of money in comparison with other countries, especially the United States, to haul goods along our lines. In the first place, it was well known that English railways had cost, roughly speaking, three times as much per mile as they had cost in the United States. This enhanced cost was due to the Government and the Board of Trade and other bodies requiring that no railway should be made at all unless it was made almost perfect, and that all branch lines should be as well made, and worked as safely as any of the main lines. That reason alone made all English railways very costly. Another great burden was the cost of

Parliamentary procedure in getting the right to make a railway. This, and the enormous amount of money that had been paid for land when taken compulsorily, had made railways exceedingly dear in this country as compared with the railways of other countries. If English railways cost three times as much per mile as those of America, there was three times the interest required upon capital, and three times the rates in order to pay that interest. The American railways worked such traffic as the haulage of coal from Wigan to London, much more cheaply than English railways. One of their methods was to use trucks weighing 9 tons, which carried 30 tons, giving a tare of 6 cwts. per ton, instead of trucks weighing 5 tons carrying 10 tons, and giving a tare of 10 cwts. per ton. There was no reason why coal from Wigan to London should not be carried in the big American waggons which carry the traffic at so much less tare. In deadweight, in which canal traffic had the advantage of railway traffic, the weight of the boat was less material, as it was floating in water; but dead weight was of great importance in railway traffic. If they succeeded in establishing water-communication throughout the country in such a way as to bring competition to bear upon the railway companies and to compel them to reduce their rates to a third of what they were now, it would be a very doubtful advantage. The result would be to reduce present railway property to something like one-third of its present value; to reduce the income of railway shareholders to one-third, and in addition, an immense sum of money would be spent in laying out canals throughout the country. We should spend enormous sums of money so as to depreciate the value of existing property. Whether that would redound to the benefit of the country in the long run was doubtful, consequently he was of opinion that an endeavour should be made to work railways more economically. They could not undo the past, but he thought that the canals should be released from the railway companies, and facilities should be afforded to independent companies to take them up and work them wherever it appeared advantageous to do so.

Mr. T. Forster-Brown said that these papers on canals contained valuable information. Mr. Wells mentioned that in France the use of canals per mile was now 84 per cent. of the user of railways, whereas in 1882 it was only 41 per cent. He thought this statement was inconsistent with the following remark: the railway carriage had increased to 7,575,000 ton-miles, and canal traffic to 2,255,625 ton-miles. The canal question, whether looked at from the point of view of Mr. Bainbridge or of Mr. Wells, was a question of expediency. In some districts, if the canals were relieved from railway control, by improving them they might be made extremely valuable for the carriage of merchandise and minerals for local consumption. It was quite evident that for carrying large quantities of coal, either for short or long distances, where speed was an essential element, improved canals could never take the place of railways. The real solution was the introduction of competing railways for the carriage of coal. He had had some experience in South Wales, where the rates had been reduced by railway competition from 0·75d. or 0·80d. per ton per mile to under ½d. A railway laid out with greater economy than the old railways might be made in many districts to carry minerals at a lower rate than the existing rates. There was one difficulty in reducing the rates, as against what one speaker said about the weight of trucks. Nearly all minerals were carried short distances, and carriages would be required for long distances as well as for short distances. He thought that existing canals not under railway control should be improved, and steam-haulage adopted; and then if good results were obtained Parliament should be asked to sanction the transfer of the possession of those other canals which were essential for competition from the railway companies.

Mr. G. E. Coke (Chesterfield) said that several speakers had spoken about the cost of traffic on the railway companies' lines being due to the increased cost of construction of English railways over those of foreign countries. He did not think that could be the actual reason, because on looking at the prices of railway shares he found that they often stood at from 50 to 100 per cent. above the cost of construction or of their original capital. It was quite evident that, though the cost was more than that of other railways, the traffic enabled them to pay dividends, which had enhanced the value of the shares considerably above the original cost. He had been lately engaged upon the question of the acquirement of the Trent navigation by the Corporation of Nottingham. The Traders' Association had prepared an interesting table, which showed the different rates charged by the railway companies where there was independent canal competition from where there was none; and railway rates were lower where there was canal competition. Messrs. Fellows, Morton, & Co., the great canal carriers, stated at the meeting held at Nottingham that if they had a 6 feet deep waterway from Nottingham to the Humber they could carry goods over that route for 4s. per ton, against the present rate of 8s. to 10s. per ton, according to the classification. He thought that all canals, in order to compete with the railways, should be controlled by some public trust, he did not think that the cost of conveyance of coal on the Aire and Calder navigation (one of the most successful of canal enterprises) was much lower than on the neighbouring railways.

Mr. H. C. **Peake** (Walsall) said that he had been sending coal by canal and by rail for twenty-five years between Cannock Chase and Birmingham, a distance of about 20 miles. The cost of haulage alone was about 1s. per ton. The canal over which the coal was conveyed was practically owned by the London and North Western Railway Company, and had not been improved for the last fifty years. There were the same small locks, necessitating the use of narrow barges, the same flights of locks, and the same heavy expenditure. Some two or three years ago, the canal company had a project for making inclined planes, which would have considerably reduced the cost of working; but it was withdrawn after being advertized, before it reached the Houses of Parliament. Possibly the new scheme would have reduced the rates from 1s. to 7d. or 8d. per ton; and, if steam-haulage had been applied, possibly the cost to Birmingham would not have exceeded 6d., or even 5d., equivalent to ¼d. per ton per mile. Some years ago he tried to work a steam-tug on the Birmingham canal from Walsall Wood to Wolverhampton, a length of 16 miles. The haulage cost 8d. per ton with horses; he worked the steam-tug for some twelve or eighteen months at a cost of about 4d. a ton. The writer of one of the papers hit the nail on the head when he said that public opinion was not ripe for steam-haulage. He had no help in his experiments with the steam-tug, everyone was against him. Nevertheless, he believed that a steam-tug could be built for £250, and it would draw five barges containing 150 tons of coal at a speed, regulated by the wash of the boats in a narrow canal, of 2½ to 2¾ miles per hour—the same rate as a horse. There was no competition between canal and rail in the Birmingham district until January of this year. The cost of conveying a barge into Birmingham from the Cannock Chase district, including boat hire, was 2s. 9d. to 3s. per long ton of 2,400 lbs., against 1s. 6d. per ton by rail, with 6d. for the truck in addition, or altogether 2s. per ton. If the improvements he had mentioned with regard to the inclined planes and steam-haulage were carried out the canal would then be able to compete on equal terms with the railway.

Mr. **Spencer** (Leicester) said that if any colliery had been dependent upon a canal during the last month or two, it would be in a very poor way. Just when they wanted the canal to take the coal away it would be frozen up. In this climate a great many weeks would have been lost at the time when people most wanted coal.

Mr. S. **Lloyd** (Birmingham) said that in Birmingham and in South Staffordshire generally they felt the heavy rates, particularly so because the only available canal-routes to the sea, except the Severn route, were in the hands of the railway. During the weather of the past month, it had been impossible to tow barges by horse-power, as, with a few nights' frost, the canals became frozen over and useless. This all pointed to the necessity of steam-haulage on the canals. If steam power were employed in the barges, they would break up the ice continually into fragments, and in ordinary seasons when there was continuous daily traffic such canals would be open all the year round.

Mr. Collier (Manchester) said that he could give his experience of the Bridgewater canal of which he was manager, and which was one of the busiest canals in England. On this canal, which was for 30 miles without any locks, there were twenty-six steam-tugs engaged, but in the present frost they were entirely overpowered, and the ice was many inches thick and quite impassable. The principal question raised by Mr. Wells was the moving of Government to take over the canals. Comparisons with what was done in other countries would, however, not be fair arguments, as there were great physical differences. England was a comparatively small country with a very large seaboard, and consequently coasting transit largely superseded canal conveyance between seaports. On the continent of Europe there were large areas of almost level surfaces where canals were easy to construct and cheap to maintain, where only railway transit was in competition, and the large watersheds afforded water supplies which in England were not obtainable. It was necessary to bear in mind all these things which made Mr. Wells's and other speakers' figures unreliable as guides and fallacious when used in comparison. Farther, the American and European statistics were based on long-leads, in some cases hundreds of miles, and over waters free from toll and not artificially constructed. Such data would be of no use to compare with the short-leads possible in England. As to steam-haulage, the speaker pointed out that this was available to-day, and the canal companies were only allowed to charge when the power was in a boat not carrying cargo, and even then was subject to the authority of a nominee of the Board of Trade as to the amount.

Lord Francis Hervey (London) wrote that the only remarks which he would venture to make, related exclusively to the inland waterways in connexion with the ports of King's Lynn and Wisbech, and were as follow:—(1) The councils of the counties interested should take the place of the too numerous and inaccessible bodies at present controlling the navigations, with facilities for joint action, so as to preclude the mischief of inharmonious administration. (2) The county councils should have the power of buying up and extinguishing the rights of toll. (3)

The direct water-route between Peterborough and Wisbech should be made effectively available for traffic; and (4) The navigations should be improved.

Mr. John T. Brunner, M.P. (Northwich) wrote that it had been a great pleasure to him to read Mr. Wells' paper, bringing together in so admirable a fashion the results of long experience, and he did not remember ever to have read a paper more full of eloquent facts. It should (he thought), especially if backed by such a resolution as Mr. Wells had suggested for adoption by the meeting, have considerable influence upon the course of legislation. He trusted that the resolution would be adopted, and would be sent to Mr. Bryce, the President of the Board of Trade. He had already discussed with Mr. Bryce the desirability of applying to the making of canals the proposed legislation for facilitating the making of light railways, and although that Minister was not prepared at the moment to go farther than saying that a very interesting question had been raised; he (Mr. Brunner) was convinced that Mr. Bryce would receive the resolution with a considerable amount of sympathy. No one could, it appeared to him, follow Mr. Wells' arguments and study his figures, without coming to the conclusion that the making of canals, the improvement of existing canals, the amalgamation of existing canal companies, and the acquisition by independent companies of canals now owned or controlled by railway companies, was of infinitely greater and more urgent importance to agriculturists and other traders than the making of light railways.

Mr. Wells, in reply to the discussion, said that he would take the questions in the order in which they had been asked. Steam-lighters had been at work on the Weaver navigation for some thirty years. The locks, built of late years, were large ones, 230 feet long by 42½ feet wide. The boats which had been constructed hitherto carried about 350 tons as a maximum, and the cargo was taken along the Weaver navigation and Mersey estuary to Liverpool. Steam-lighters were also used for towing three other lighters, sometimes more, but usually three, and the locks could take them all in at once, and thus something like 1,000 tons was lowered or raised from one level to another. The size of the canals was a matter of very great importance, as it not only fixed the size of the vessels, but to a very great extent it regulated the speed at which they might navigate. The speed on the Weaver was regulated by the cargo, no restrictions being imposed. A steam-lighter, the cargo of which was wanted in Liverpool in haste, went singly at the rate of 4 to 5 miles per hour; and every barge that was added to her load diminished the speed.

The most economical way of working was to take ample cargo, and, as far as he could judge, the custom of the carriers was to load as deep and build as large a vessel as circumstances allowed. When he took charge of the Weaver navigation the draught of water was 7 feet 10 inches, but when he left, the draught was 10 feet. The shorter locks were removed, so that about 5 feet could be added to the length of the vessels throughout the navigation. He found that the salt-owners, as the dimensions of the locks permitted, not only built larger boats, but raised and lengthened the old ones. That was practical experience of what was worth doing to obtain economy in transportation. The cheapness of steam-haulage was dependent in a great measure on the tonnage. A horse would tow a small cargo almost as cheaply as a steam-boat. But with trains of boats, steam-haulage undoubtedly was the cheapest. He was certain, although traffic on canals may have increased somewhat during the last ten years, that it bore no comparison with the increased traffic on railways. Practically, canal traffic stagnated while railway traffic increased rapidly. On the contrary, in France and Germany, year after year water traffic was relatively increasing in greater proportion than railway traffic. Some remarks had been made as to the difficulty of treating coal-traffic economically by water, because of the frequent changes and breakages and so forth. Messrs. Cory & Sons, London, had built lighters to carry 350 tons, these were loaded in the Trent and towed to London, the same collier taking in tow one, two, or three of these lighters, according to the season of the year, and the cargo was delivered in the docks at London, above or below bridge. It is intended that these lighters shall trade on the Aire and Calder navigation ; they can traverse many miles, but cannot reach any colliery at present. There are one or two bridges which have to be altered, as the lighters stand about 13½ feet out of the water when light. As soon as the alterations contemplated have been made, these lighters will be able to load from six collieries in the West Yorkshire district. The coal will be tipped direct from the tubs used in the mines, and taken to London without farther transhipment. This means of transport had now been in use for four months (the worst months of the year) and might be considered to be established, Messrs. Cory & Sons being quite satisfied with the experiment. The lighters could be taken to the collieries in the South Yorkshire coal-field if the Sheffield navigation were improved at the lower end, and this need not involve an excessive outlay. The compulsory purchase of canals by the Government was not advocated by the speaker, and his present attitude towards the matter was one of enquiry. Canal navigation demanded very careful consideration in this country, especially when we found that continental nations were willing to spend large sums of money on improving their waterways. He had lately been in Germany and found that salt-mines (in the centre of Germany, having water-communication with Holland, Belgium, and Hamburg) had shut out English salt from Holland and Belgium to a great extent, and were actually sending salt to Newcastle-upon-Tyne (being transhipped at Hamburg). This latter competition was rendered possible, owing to the very cheap carriage down the river Elbe and by sea. He did not find that the German salt-miners worked longer hours or were paid lower wages than our miners. He was told that they commenced to work at 6 a.m., had half-an-hour for their meals, and came out of the mine at 2·30 p.m. That was exactly the same time as salt-miners worked in Cheshire. He also understood that they earned within a fraction the same wages as were paid in Cheshire. One could imagine, for train-loads of coal from Wigan to London, that larger trucks would be an advantage. It must be recollected that English railways had been made to accommodate the existing truck, and if larger trucks were adopted, the probability was that their wheel-bases would be larger and the curves would not be so readily negotiated as they were by the present description of waggon. He did not think that a great reduction of value of railway property should be feared if inland navigations were improved. Traffic led to traffic, and facility for traffic bred traffic. So far as railways in America were concerned those were the first to adopt improvements and a low transport rate which ran in competition with the grand system of navigation from the Western lakes to the Atlantic seaboard. The Erie canal had been a great factor in the making of New York, and unless that canal had been in existence the port of New York would not have gained its present commercial position. It had also been shown that the improvement of the Rhine navigation had not been destructive of the railway traffic along its banks. Some members talked of the possibility of reducing railway rates to 0·25d. per ton per mile. That, of course, was a very great reduction on existing rates, but the traffic from Chicago to New York was carried by water for 0·10d. per ton per mile. An authority said that the Americans had cut their railway rates down to 0·40d. per ton per mile, but the same authority which gave 0·40d. for railway rates gave 0·20d. for rates by water. The question of canals being frozen, and therefore forming unsatisfactory means of transport, was one which might be expected to be raised at this season, but he should like to remind members that the canal which carried most traffic (more than the Suez Canal) was open on an average for 220 days per annum. In 1892, it carried 11,000,000 tons in 230 days, and until recently only one lock was provided. He referred to the Sault St. Marie canal. He therefore did not think that the fact that canals were closed for a certain number of days by frost, although it was a great detriment and hardship to many people, was a valid reason for saying that canals were unworthy of trust or unworthy of being improved and used. The secretary had read a letter from Mr. Brunner, M.P., chairman of Messrs. Brunner, Mond, & Co., who was fully conversant with the business of his firm. The works at Northwich alone receive upwards of 400,000 tons of coal; limestone, and other materials per annum, and the company have other works on the Trent and Mersey canal, Leeds and Liverpool canal, and also on the river Thames. Mr. Brunner was very strongly in favour of a resolution being taken from this meeting, but the President had ruled that to be out of order. What appeared to him (Mr. Wells) to be open in the matter of inland navigation was this:—The Government under a certain amount of pressure were prepared to bring in a bill to give facilities for making light railways. If any persons who were interested in canals had suggested such a thing on their behalf, no doubt the railway interest would have been exerted to prevent anything of the sort from taking place. It appeared to him that when the bill was before the House, and it was seen that there were provisions introduced into it by which land could be acquired more readily and expensive forms avoided, if some member would move that the bill should include canals, then we should possibly find there was no real reason why canals should not reap the benefit, and canals would undoubtedly be included. He hoped that might be so. Mr. Collier referred to the comparison of rates here and abroad as not altogether fair. He thought that Mr. Collier's criticisms were perfectly fair. If a parcel was carried a few miles and several canals were passed over, the charge would be more per mile than if carried for a longer distance or by one company. He (Mr. Wells) wanted to see the mileage of canals increased under one management. When this was done, it would be found that canal traffic could be worked at a less rate than it was at present. The advantage of large canals over small ones was shown thus:—the Bridgewater, the best of the shallow barge-canals, well worked and managed, only took about one-third of the coal from the Bridgewater collieries, two-thirds being carried by rail. The Weaver navigation, when he (Mr. Wells) was connected with it, took two-thirds of the output of the salt-works and left one-third for the railways. That seemed to him to point to the advantage of a large canal as compared with one of less capacity. What he would have liked if the Institution could have seen its way to do so, was that a resolution should be passed asking the President of the Board of Trade to call for returns supplementary or somewhat similar to the return made in 1888; but in the light of the information which had been gathered since then on the subject. That return was essentially incorrect in many points, and did not go far enough. At present, personal knowledge was the only trustworthy guide. He need not call attention to the errors of commission and omission. They were palpable to any one referring to a canal he was intimately acquainted with. The authorities at the Board of Trade appeared to have entered in the Blue Book, without any question or criticism, whatever information was sent to them. Certain canals had given correct information so far as they had been asked for it, others had not. There are many canals on which the locks varied in size, and in which the depth of the water varied. There was no indication in the Blue Book in many cases as to this variation. Anyone attempting to work from it would inevitably be misled. The returns under the head of maintenance of works and management were also comparatively useless: the questions, he thought, could not have been put sufficiently clear; at any rate any answer which was received seems to have been entered, so that on the Lancaster canal it is said to have cost £49 per mile, and on the Shropshire Union £539 per mile for a similar service. No useful information could be gathered from such returns. There was no reference to the headway under bridges. This was a very important point. Mr. Jeans alluded to the inability of canals to compete with railways in density of traffic. He (Mr. Wells) could not understand the paragraph. The canal was not merely a thoroughfare, but also a siding. The more crowded the banks were with wharves and factories the better, so long as the waterway was sufficiently wide to allow for traffic passing while vessels lay at the wharves. Priestley's map referred to by Mr. Saner was well known to the writer. It was, he supposed, sixty years old. Not only were derelict canals shown by the same colour as those in use, but many canals which were never constructed were also shown in a similar manner. Mr. Peake's experience and statements of the cost of transport by canals in the Midlands was most valuable testimony in favour of amendment. To possess canals which could not or did not compete with railways was an anachronism, and ought not to be tolerated any longer. No doubt there was a Railway and Canal

Commission, but owing to the cost of presenting a case and the proverbial uncertainty of law it was seldom invoked. A readier means of securing the object sought was imperatively demanded.

Sir E. LEADER WILLIAMS (Altrincham, Cheshire) wrote that the question of the future of the canal system of England was a most important one for the trade of the country. It was at one time thought that the introduction of railways rendered canals of comparatively little use, and the owners of the canals were glad to dispose of their property, in many cases, to the railway companies, who were equally willing to become purchasers in order to reduce competition, and also, in some instances, to facilitate the construction of their lines. The result had been to block the progress and improvement of canals at home, while abroad the full development of waterways had advanced rapidly, without unduly interfering with the construction of railways. The experience of other countries proved that both were advantageous to the development of trade, as canals could deal with certain classes of traffic more cheaply than railways, which must always have an advantage where speed of delivery was necessary. As traffic increased, the railway companies had largely increased their capital expenditure, with little if any advantage to their shareholders. The necessity of mixing up fast passenger traffic with slow goods and mineral trains had compelled the railway companies to double large portions of their main lines and to increase their siding accommodation. If canals had been improved at the same time that railways were being constructed trade generally would have benefited by lower rates of carriage, and this would not have injuriously affected railways, whose capital expenditure would have been less, while they would have had their share of the advantage of the improved trade that would result from reduced charges on heavy goods and minerals. The question now to be considered was, how to place canals on a proper footing. The cost of improving them must be large, and it was only by enlarging the main lines of narrow canals and giving increased depth, on an uniform system, that any real advantage would be gained. Once constructed, a proper barge-canal had great advantages over railways. Fast or slow traffic could pass at any point, and as there was no renewal of permanent way, the cost of maintenance was small, and remained almost stationary, even if the traffic largely increased. Taking Birmingham as a centre, no one could doubt that the improvement of the canals that connected the Midland district with the rivers Mersey, Humber, Thames, and Severn would be of great advantage, but it was doubtful, without the aid of Government, whether the capital necessary could be found for even one of these improved lines of communication with the sea. Yet it was a point to be considered, looking at the necessity for reducing the cost of carriage, in order to better enable us to compete with other countries who had already constructed large barge-canals at the public cost. And seeing that the expenditure would be entirely at home, giving employment to home labour, it was a question whether it would not be advantageous to the country (now that capital could be raised at a low rate of interest on Government securities) to bring the numerous smaller canals into one public trust, with the object of bringing them uniformly up to date, so that they might again take their place as important agencies for the development of trade and commerce.

Mr. J. A. Saner (Northwich) wrote in reply to the discussion that he thought Mr. Hunter had not fully grasped the object of his paper. He was quite in accord with the opinion that, when possible, coasting traffic should be provided for, but the dimensions laid down in the writer's paper were for purely artificial canals, such as the proposed Weaver-Birmingham canal, running through thickly populated districts, and encountering innumerable obstructions, such as railways, roads, scarcity of water, etc. It was in such cases, which would be in the majority, that he was of opinion that his standard dimensions, allowing for barges of 300 tons burthen, would be the largest practicable. He hoped within measurable time to see coasting steamers of 500 tons at Winsford on the Weaver, and was of opinion that all rivers of a similar calibre should be, if possible, made available for such craft. He thought if the experiment, mentioned by Mr. Wells, which was being tried by Messrs. Cory & Sons, of towing 350 tons lighters from the Trent to London, was a success, that there would be no reason why the same lighters could not traverse such a canal as he had suggested with the greatest ease, and amply provide for the trade which Mr. Hunter, in conjunction with all other engineers who had studied the subject, wished to see accommodated. Mr. S. Lloyd, of Birmingham, was right in conjecturing that if steam power were used on canals that they could be kept open in winter. The use of steam-tugs alone would not be sufficient, unless provision were made for clearing away the ice after it had been broken, as after several consecutive nights of severe frost the broken pieces congeal together and become so tough that even steam is of no avail, and although the pieces may be kept apart, the risk of damage to the steamers' propellers was anything but a theoretical risk. He had managed, by dint of most strenuous exertions, to keep the river Weaver open for traffic during the whole of the recent frost (six weeks), although the ice in unbroken places attained a thickness of 8 to 9 inches; but this result had only been obtained by the constant running of steamers and the labour of large gangs of men who were employed in pushing the broken ice over the weirs. The weirs were specially provided with ice-caps, and the accumulations in the bye-passes below were in some cases 15 to 16 feet in thickness, and extended for from 100 to 300 feet in front of the apron of the weir. Although it might not be possible to keep open such a canal as he had suggested, for the whole duration of such a frost as had recently been experienced, yet with proper provisions, such as above described, he had little doubt that the stoppage would be only a day or two in duration, and nothing in comparison with the trouble now being experienced by the present small canals.

The President was of opinion that Mr. Wells and the other writers of papers had made out a very strong case in favour of the farther development of canals, and he believed that the balance of opinion of the members was to the same effect. He believed that the papers would prove a valuable addition to the *Transactions* of the Institution, and although the Institution might not be able to pass such a resolution as Mr. Wells had suggested, he thought that the discussion at that meeting would materially strengthen the hands of all persons interested in the more efficient working and management of canals.

Mr. Emerson Bainbridge (Sheffield) proposed that the thanks of the members be given to Mr. Wells and the authors of the other papers under discussion. He might not have been successful in having a resolution put forward from this Institution, but there would be no harm in those members who were connected with the Mining Association of Great Britain bringing it before that association.

Mr. G. J. Binns (Netherseal) seconded, and the resolution was carried unanimously.

Mr. E. D. Marten read the following paper on "The Severn Navigation, with Particular Reference to Recent Improvements":—

THE SEVERN NAVIGATION, WITH PARTICULAR REFERENCE TO RECENT IMPROVEMENTS.

By E. D. MARTEN, M. Inst. C.E., Engineer to the Severn Commissioners.

The river Severn may be regarded as consisting of four distinct sections. First, there is the uncanalized river from its source in the Welsh hills to Stourport. A portion of this, from the Shropshire coal-field downwards, is navigable in the winter months, but it is now little used.

The second section is the canalized length of 42 miles from Stourport, through Worcester to Gloucester. It is this section which forms the subject of the present paper.

The third is the tidal estuary from Gloucester to Sharpness, which is so exceedingly tortuous and so choked with shifting sands that more than one hundred years ago all attempts to use it as a waterway for sea-going vessels were abandoned, and the Gloucester and Berkeley ship-canal commencing in the canalized portion of the river at Gloucester, and terminating by a junction with the river again at Sharpness, was constructed. This ship-canal is 16 miles in length, as compared with about 26 along the river-course which it has superseded, and it allows of the passage to Gloucester of vessels of about 600 tons burthen.

Finally, there is that section of the river from Sharpness to the Bristol Channel which is practically an arm of the sea.

At Stourport, where, as above stated, the canalized portion of the river commences, the Staffordshire and Worcestershire canal enters, and at Worcester, some 12 miles lower down the river, the Worcester and Birmingham canal comes in. Both of these canals are connected with the ramified canal-system of Birmingham and the Staffordshire Black Country, which at Stourbridge is only 14 miles distant from the Severn at Stourport, whilst from the city of Birmingham to Worcester it is 30 miles by canal. By means of these two canals the Severn is connected with the Mersey and the whole of the canal-system of the North of England, including the Manchester ship-canal.

Traffic is conducted along them by means of the ordinary canal-boat of 7 feet beam and carrying from 25 to 35 tons, and on reaching the Severn one of two courses is adopted with respect to it. If it be intended to be shipped from Gloucester, no transhipment occurs, as the canal-boats proceed down the river and tranship over the ship's side at Gloucester. If on the other hand the traffic is intended to be delivered at or shipped from Bristol or other Channel ports, it is, on reaching the Severn, transhipped into a class of vessel known as a "trow," the carrying capacity of which is from 80 to 100 tons, and which is sufficiently seaworthy to face the rough weather sometimes met with in the Severn estuary below Sharpness. Import traffic is conducted on much the same lines.

The haulage is for the most part effected by means of steam-tugs and is conducted in fleets or trains, as many as twenty-seven boats having at times been drawn by a single tug.

The navigation is divided by means of the locks and weirs into six pounds, from the lowest of which the Gloucester and Berkeley ship-canal locks up, and it is at one level for the whole 16 miles, at the end of which it locks down again into the Severn estuary.

The three locks above Worcester admit of the passage of a vessel about 85 feet long by 15½ feet beam and drawing 6 feet of water.

The two locks below Worcester, however, namely, the Diglis lock near that city and the Upper Lode lock at Tewkesbury, are of sufficient size to admit of the passage through them of vessels which, if built on the ordinary lines, might have a length of 135 feet, a beam of 22 feet, and a draught, when the river was at dead low summer-level, of 9 feet; in other words a sea-going steamer capable of carrying, in addition to her machinery, some 300 tons of cargo.

Until recently, however, it has not been possible to derive any advantage from these large-sized locks for two reasons.

Firstly, because the lock from the river into the Gloucester and Berkeley ship-canal, although long enough and wide enough for a vessel such as that above-named, would only admit of the passage of a vessel drawing about 7 feet 8 inches.

Secondly, because the channel of the river between Worcester and Gloucester, although of ample depth and width for about 18 miles out of 30 miles, the distance between those two cities, was blocked for the remaining 12 miles by certain shoals which restricted the draught of vessels using the river to 6 feet at low summer-level. These shoals were not confined to one particular length of 12 miles of the river, but were scattered about, some being near Gloucester, others near Worcester, and the remainder at intermediate points.

In the year 1889, these facts having been brought under the notice of the Severn Commissioners (who are the authority responsible for maintaining the navigation of the 42 miles of river between Stourport and Gloucester) by the writer's late father, Mr. Henry J. Marten, who was then their engineer; he was instructed to make a new survey of the bed of the river and report to the Commissioners as to the cost of dredging a channel, with a minimum depth at low summer-level of 7 feet from Stourport to Worcester Bridge, and of 10 feet between Worcester Bridge and Gloucester, so as to enable vessels to take full advantage of the size of the locks below and above that point. The channel so cut to have a bottom width of 40 feet in both cases.

He accordingly reported on August 24th, 1889, to the effect that the cost of dredging the channel to a depth of 7 feet everywhere above Worcester Bridge would be £1,702 17s. 8d., and the cost of dredging the 10 feet channel below Worcester Bridge £12,227 18s.

Acting upon this report, the Severn Commissioners went to Parliament, and in 1890 obtained an Act empowering them to raise £30,000 and to expend it on the following works:—

(1) The making of certain structural alterations in the shape of the bottoms of the three locks above Worcester Bridge, so as to admit of the passage of square-sided vessels measuring 15 feet 6 inches in their widest part and drawing 6 feet when loaded.

(2) The deepening of the channel as aforesaid to a minimum depth of 7 feet above Worcester Bridge.

(3) The deepening of the channel between Worcester Bridge and Gloucester to a minimum depth of 10 feet at low summer-level.

(4) The deepening of the entrance-lock to the Gloucester and Berkeley canal, so as to admit of the passage through it of vessels drawing 9½ feet.

(5) The construction of a transhipping-dock at Worcester with a depth of 10 feet, including the purchase of about 30 acres of land.

These works were commenced on July 2nd, 1891, and were completed on June 30th, 1894. They were designed, and for the most part carried out by the writer's late father, Mr. Henry John Marten, but on his death at the end of 1892, their completion was entrusted by the Commissioners to the writer.

The writer is pleased to say that they were carried out well within the estimates, so that notwithstanding the fact that certain extra items of expenditure, not included in the original estimates, were imposed upon the Commissioners during the passage of the Bill through Parliament, and notwithstanding also that the cost of the Act itself greatly exceeded the sum which was provided for it, there remained on the completion of the works a balance of some £200.

The engineering operations were, for the most part, of a simple character.

The transhipping-dock at Worcester is about an acre in extent, but the Commissioners have, as stated, acquired some 30 acres of the surrounding meadow-land, so that there is ample space for extensions as soon as the trade develops. The water in the dock rises and falls with the water in the river, and it is everywhere 10 feet deep at low summer-level. A concrete quay-wall 300 feet long has been built along one side of it, behind which a metalled quay-space, 150 feet wide and 9 inches above the level of the highest recorded flood, has been left.

The action of the Commissioners in constructing the quay-wall and quay, without also providing warehouses or shedding, or any appliances for landing goods, has been somewhat harshly criticized, but a little reflection makes it clear that they have exercised a wise discretion both in what they have done and in what they have left undone. In proof of this opinion, the writer may point out that the main necessity for a transhipping-dock in connexion with the improvement scheme was that there should be a suitable place where transhipping might be effected without its having to be done in the open river, to which there were many objections. For such a dock, however, no quay-wall or quay was necessary, nor was it contemplated in the earlier stages. As matters developed, however, the suggestion was made that a quay-wall would most certainly be required as the traffic increased, and that such quay-wall could be constructed much more cheaply while the excavation for the main basin was being done than would be the case at any time after the water had been let in. This view of the case appeared to be so reasonable that the Commissioners determined to include its construction in their scheme. It was impossible for them to go beyond this, however, for the simple reason that no information existed as to the class of merchandize that would be likely eventually to make use of the quay, and it is hardly necessary for the writer to point out in this paper that warehouses, shedding, and appliances and machinery for unloading vessels must vary considerably in design according to the goods to be dealt with. Any outlay in this direction, therefore, in the present imperfect state of information as to the nature of such goods, would probably result in unnecessary and wasteful outlay. There is ample land for storing timber, flints, china-clay, etc., and for the erection of warehouses and sheds.

The entrance to the dock is 40 feet wide, and is crossed by a swivel foot-bridge. The quay-wall and bridge-abutments were composed of 8 to 1 cement concrete faced with 5 to 1 cement concrete. Excellent gravel for the purpose was found in the excavation, and not a single brick was used on the work. The wall rests upon a firm foundation of hard marl-rock.

The dredging of the new channel was mainly in sand and gravel, and presented little difficulty, but there were exceptions to its generally easy nature. The most important of these consisted of two barriers of hard marl-rock, one at Bunns Hill Ford, near Worcester, extending along the river for ¼ mile, and the other at Wainlode Ford, about 7 miles above Gloucester, which was about ½ mile in length. The channel over these barriers was only 6 feet deep when the water was at summer-level, and that depth was only found for a width of about 20 feet. It will, therefore, be seen that in order to cut a channel 10 feet deep and 40 feet wide, a face of solid marl-rock of that width, and averaging from 5 to 6 feet in thickness, had to be broken up and removed.

In former times, attempts had been made to break up these rock-shoals by means of blasting, but that was found to cost about 5s. per cubic yard removed, and the writer's late father therefore determined to try the system which has been successfully adopted by Mr. Messent in dredging rock on the Tyne. This method consists in breaking up the rock by means of powerful wrought-iron claws with steel points attached to the bucket-chain of the dredger. In the Severn operations every alternate bucket on the dredger-chain was removed, and a pair of these claws substituted for it, and the dredger was then set to work at the face of the rock in the usual way. The claws broke the rock up, ploughing into it with irresistible force, and either they themselves or the remaining buckets brought it to the surface. The rock dredged was sometimes as hard as building-stone, and lumps as big as a large sheep have been landed, but it was unfortunately useless for any purpose, as it crumbled away in a few weeks when exposed to the air. After much careful and anxious experiment, it was found that the best and most durable description of link-pin to be used for rock dredging was one of manganese steel. Anybody who has had any practical experience of rock-dredging will understand how important it is to use a link-pin which is neither brittle nor soft. These requirements were exactly met by pins of manganese steel, the only others which were of any use for the purpose being some special wrought-iron pins made by Messrs. Horton & Son, of Darlaston.

The cost of dredging this rock, including coal, stores, labour, and disposal of dredged material, was about 2s. per cubic yard, but this price did not include anything for hire of plant, as the Commissioners did the work themselves, and used their own dredgers.

About 12,000 cubic yards of this hard marl-rock was dredged altogether, and it was mainly used in forming training-embankments at places where, owing to the abnormal width of the river, there was any tendency for silting to take place in the newly dredged deep channel, and such embankments have proved particularly useful for the purpose.

Prior to the commencement of the dredging operations predictions were not wanting that in some places the channels would silt up as quickly as they were dredged. It is found, however, that this is not the case, the only tendency to silting being at places where the river is curved and also of abnormal width, with the deep channel on the convex side. At such places the evil has always been overcome by means of these training-embankments.

The other works presented no features of particular interest.

Were it not for the fact, which the writer has already mentioned, that a depth of 10 feet or more existed for the greater part of the length prior to the commencement of the operations, it would be hard to realize that for the sum of £10,000, or thereabouts, the 30 miles of the Severn, from the port of Gloucester to the city of Worcester, has been converted from a mere barge-canal into a highway for sea-going steamers, capable of carrying 300 tons of cargo. In other words, that for this small sum Birmingham, Wolverhampton, and the South Staffordshire mining district generally, have practically been brought 30 miles nearer to the ship's side than they were prior to the carrying out of the operations which the writer has described. The fact, however, is established, the works are completed, and the river is ready to-day for the passage of a vessel of such build as the writer has described.

Owing to the existence at Gloucester, however, of the Westgate Bridge, which is a low stone-arched bridge, having a headway of only 18 feet at low summer-level, it is necessary that sea-going vessels for the Worcester trade shall be of somewhat different construction from those generally employed for sea-going purposes, but up to the present time no such vessels have been constructed. Indeed, the only advantage that has so far been taken of the improvements which have been made in the navigation is that certain grain-vessels coming from Cardiff now load down to their maximum draught of 7 feet 3 or 4 inches, whereas formerly they were restricted to a draught of 6 feet at low summer-level.

Considering the enormous benefits likely to accrue to Birmingham and the South Staffordshire Black Country from being brought, as above stated, 30 miles nearer to the ship's side than heretofore, it has been a matter of some surprise to the Severn Commissioners that no steps have been taken to reap the advantages to be derived from the facilities which they have provided; especially as the toll remains the same as (or indeed, as the result of recent legislation, somewhat less than) it was prior to the construction of the improvement-works. The funds for carrying out the works were lent to the Commissioners on mortgage by various corporations and other interested persons, the interest to be payable out of any increase that may arise in the income from increased traffic resulting from the improvements, but neither interest nor principal can be recovered except from that source.

It having been suggested that the delay in constructing suitable steamers arose either from a general want of knowledge with respect to the existing depth of the Severn, or from some uncertainty in the minds of traders as to whether it were possible to build sea-going steamers of the class which should be capable of navigating under the Westgate Bridge at Gloucester, the Severn Commissioners have recently been taking such steps as lay in their power to get together information upon the matter, and give it the fullest publicity.

Amongst other things it came to their knowledge that improvements very similar to those on the Severn have recently been carried out on the Seine from the port of Rouen up to Paris, and that notwithstanding the existence of certain bridges very nearly as awkward as the Westgate Bridge, sea-going vessels were trading between the ports of Liverpool and London and the city of Paris. Consequently they instructed the writer in October last to obtain what information he could with respect to the navigation of the Seine, and report to them thereon. The writer accordingly visited Paris during October and reported to the Commissioners on December 18th, 1894, and this report has by their orders been printed and widely circulated.

As stated in that report, the writer found that three sea-going steamers whose tonnage varied from 140 to 500 were trading from English ports to Paris. Two of these, belonging to Messrs Burnett, of London, had been regularly trading for the past ten years, whilst the third was a new venture trading from Liverpool.

The writer also found that the navigable depth of the Seine was 10 feet 5 inches as compared with 10 feet, the present navigable depth of the Severn.

On the Seine, there are three bridges, under all of which the sea-going steamers have to pass, the headway of which is but little in excess of that of the Westgate Bridge at Gloucester. It will be seen from Fig. 1, that one of these, the bridge of Sèvres, although nominally having a headway 4 feet greater than the Westgate bridge, is constructed with so narrow and pointed an arch that for the purposes of navigation it is hardly any better than that bridge. Mr. Rabel, the engineer-in-chief of the portion of the Seine where this bridge is situate, informed the writer that in times of high water it was a bar to traffic, and on that account it would shortly be reconstructed. As a general rule however it in no way blocked the sea-going vessels. Its case is therefore in every way analogous to that of the Westgate Bridge, which the Commissioners intend to alter whenever they may be provided with funds for the purpose, as it not only blocks sea-going steamers, unless of special construction, but it also blocks all traffic in times of flood. It is unnecessary, however, for the Midland districts to wait for this—at present—somewhat indefinite date, when the advantages to be derived from what has already been done may be reaped immediately by a small and remunerative outlay. The headways of the other two Seine bridges referred to are 2 feet and 2 feet 6 inches respectively greater than that of the Westgate Bridge.

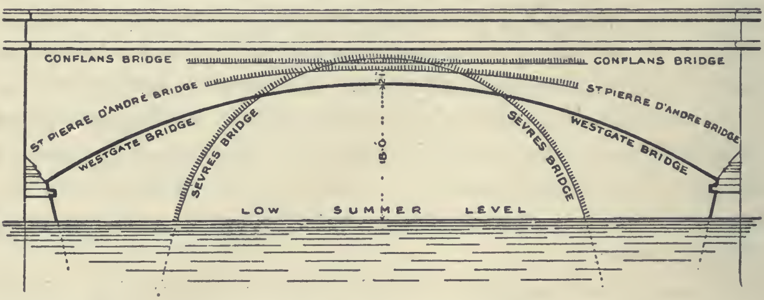

Fig. 1.—Westgate Bridge, Gloucester, showing the Comparative Outlines of the three worst Bridges on the River Seine.
Scale, 26 feet to 1 inch.

The locks on the Seine are longer than those on the Severn, and consequently it is possible to build steamers to navigate to Paris with 500 tons on board, whilst the Severn steamers would be restricted to 300 tons. This, however, would be a very paying size, as is shown by the fact that one of the Seine steamers carries only 140 tons and has been running between London and Paris for ten years.

At the present time, goods going by water from the Birmingham district to Continental ports are carried in narrow canal-boats, through Worcester to Gloucester, a total distance of 60 miles, and there they are transhipped into the sea-going steamer. This often has no greater carrying capacity than the vessels which the writer proposes for the Worcester trade, but which, not being of special construction, are barred by the Westgate Bridge.

It is quite certain that the cost of transport must be greatly reduced when half of this 60 miles journey is made in one bottom instead of ten or twelve, as would be the case if the transhipment took place at Worcester instead of Gloucester.

What the writer saw on the Seine convinced him that it was feasible to construct sea-going vessels capable of navigating the Severn river up to Worcester. As an additional proof of this, he may mention that some thirty-five years ago two sea-going steamers named the "Ironside" and the "Cuirassier," carrying respectively 120 and 140 tons, were built and worked between Worcester and the French and Irish ports. The length of these vessels was 94 feet, their breadth 19½ feet, and their draught 7 feet. Unfortunately, like a great many other good things, these vessels were a little before their time, as the weirs at Gloucester were not constructed at that date, and the consequence was that in summer time the water in the river between Gloucester and Tewkesbury, a distance of 13 miles, used to fall to so low a level that these comparatively deep-draughted vessels had to give up the Worcester trade. They continued, however, to trade between Gloucester and Irish and Continental ports for many years, and the writer has been told that the old "Cuirassier" is still at work on the East Coast.

A design for a steamer to comply with the existing conditions of the Severn navigation in all particulars, and to carry 290 tons, with a 9 feet draught, has been submitted to the writer by a firm of Glasgow shipbuilders, who undertake to build and fit such steamers out complete with machinery of sufficient power to drive them when at sea and loaded, at the rate of nine knots (say, 10¼ miles) per hour, for the sum of £5,600 each; and the writer has no doubt that if there were a prospect of much business being done that the shipbuilders would be prepared to make a considerable reduction from that amount.

Such vessels would trade with Ireland and the Continental ports, to say nothing of the large coasting-trade which might be done with other ports in Great Britain.

As an instance of what is possible in this latter direction, the writer may mention that at the present time copper is carried by two vessels called the "Jesmond" and the "Cheviot" from Newcastle-upon-Tyne to Gloucester, whence it is forwarded to Birmingham by canal, it being found cheaper to send by this circuitous route rather than direct by rail from Newcastle-upon-Tyne to Birmingham, although the distance by rail is only 210 miles, and the distance by sea and inland navigation exceeds 900 miles, 75 of which are over inland navigations. The "Jesmond" is only a very little too large to use the Severn navigation. If she could do so, the cost of carrying between Newcastle-upon-Tyne and Birmingham might be still farther reduced.

The writer mentions this case as one instance merely of the possibilities which exist for over-sea traffic from Worcester (within 30 miles of Birmingham) as a port, and many more occur to him, but this part of the question is more one for examination by a trading expert than by an engineer.

The writer's province, as engineer to the Severn Commissioners, is to make the public aware of the facilities which exist, and this he has endeavoured to do. It is for the public to avail themselves of those facilities or otherwise as they may feel disposed.

The Severn Commissioners have done all that their statutory powers permit them to do, they being much in the position of a highway board whose powers and duties extend only to keeping a good road. This they have done and are doing, and all they ask is that the trading public of Birmingham and South Staffordshire will come and make use of it. This, it will be admitted, is a modest request. There is no suggestion that a prolonged and costly Parliamentary struggle, such as Lancashire had to go through before it got power to make the Manchester ship-canal, shall be entered upon. No outlay of unknown millions has to be faced in the construction of the waterway. All that is done. Neither is there any uncertainty about the toll, as there is no power to increase it, and by Act of Parliament it is one of the lowest in the kingdom.

All that is required is for the traders to invest some £50,000 or £60,000 (a fraction only of what Lancashire spent in mere Parliamentary fighting) in what the writer believes would turn out to be an exceedingly sound and profitable enterprize, namely, the construction of a small fleet of over-sea steamers to trade from Worcester as a port. The writer says a small fleet advisedly, for he is of opinion that it would not long remain a small one, and that the investment would turn out to be so profitable, if well managed, that additions would be very soon made to the fleet. He commends the investment to the consideration of the trading public in Birmingham and the Midlands as one from which they would probably earn a double profit, as, firstly, there would be the gain resulting from the reduction in the cost of carriage, and secondly, there would be the profit resulting from the carrying trade, which might still be handsome even after the rates were largely reduced.

The writer wishes it to be understood that he makes these suggestions without the least unfriendly feeling towards the existing carrying firms on the river, several of which have been established for very many years, and between whom and the Severn Commissioners and their officers excellent relations have always been maintained. Even if these firms did not themselves go into the over-sea trade the writer believes that they would reap a great advantage by its establishment, as all the over-sea traffic must be brought by ordinary canal-boat from the Birmingham and South Staffordshire districts to the ship's side at Worcester, so that whilst these carriers are not likely to lose a single ton of their existing trade they would probably get a large increase of business by this means.

Finally, while calling attention to the advantages which Midland traders may immediately derive from the Severn navigation in its present improved state, the writer is nevertheless anxious that the still greater advantages which would result from the conversion of the Westgate Bridge at Gloucester into an opening bridge, shall not be lost sight of. If this were done, any vessel, no matter how high out of water she stood, could pass through it if her dimensions did not otherwise exceed the capabilities of the navigation as previously described; and the writer is informed by a gentleman who subscribed largely to the fund for making the recent improvements, who is also a shipowner at Cardiff, and trades thence to the Midlands, that there already exist many sea-going vessels that would use the navigation under such circumstances, but which are now barred by the bridge. The cost of the suggested alteration is estimated at £11,250, but this does not include Parliamentary expenses and several other items, so that it is probable that powers to borrow £15,000 would have to be sought in any application to Parliament.

In addition to the Westgate Bridge, there are two other fixed bridges on the navigation between Gloucester and Worcester, but as each of these has a headway 7 feet higher than that of the Westgate Bridge, their case is not urgent. Until these are also converted into opening bridges, however, it cannot be said that the navigation of the Severn to Worcester is free to all ships that sail the seas.

The writer is of opinion that the day will come when, not only will all these improvements be carried out, but also the much greater one of so deepening the river and enlarging the locks as to allow of those vessels of 600 tons which now navigate the ship-canal to Gloucester, proceeding to Worcester. Nature has already done two-thirds of the work necessary to bring about this result, so that the task which remains is comparatively a small one.

The Severn Commissioners, however, have no funds which they can apply to these purposes. They have always shown themselves willing to spend for the public good any funds entrusted to them with the view of improving the river, and the gratifying result has been that rates, both by rail and water, from Birmingham to the Bristol Channel ports, are considerably lower than in other directions.

The cost of future improvements must, like those in the past, be provided by the trading public interested in the matter, and it appears to the writer that it is for the Midland traders themselves to decide whether it is more to their interest to spend money in building sea-going steamers to use the navigation in its present state; or whether they prefer to provide the funds for altering the Westgate Bridge, and possibly for carrying out the other improvements which have been glanced at in the course of this paper; or whether, finally, as an alternative they are content to do nothing at all in the way of taking steps to mitigate the serious disadvantage at which they are placed in competition with others by reason of their inland situation.

Mr. L. F. Vernon-Harcourt read the following paper on "Inland Navigation, with Special Reference to the Birmingham District":—

INLAND NAVIGATION, WITH SPECIAL REFERENCE TO THE BIRMINGHAM DISTRICT.

By L. F. VERNON-HARCOURT, M.A., M. Inst. C.E.

Inland navigation has received much greater attention, and has been more largely developed on the Continent than in Great Britain during recent years, more particularly in France and Belgium. In France, as in England, the introduction of railways led to the neglect of inland navigation; but, after the lapse of about twenty years, interest in waterways revived in France, and considerable improvements in rivers, and extensions and enlargements of canals have been carried out.

Standard Dimensions for Inland Waterways in France.—When waterways came to be regarded in France as of national importance for the prosperity of the country, notwithstanding the large development of railways, the differences in the depth of the various canals, and in the sizes of the locks, were recognized as serious impediments to the due development of inland navigation. Accordingly, in 1879, the Government issued a decree that all the main lines of inland navigation in France should be given minimum uniform dimensions as follows:—Depth, 6½ feet; locks, 126⅓ feet long, 17 feet wide, and 6½ feet depth of water on the sills; and a minimum headway under bridges of 12½ feet. By thus obtaining a standard depth, and locks of uniform size, by works gradually carried out, vessels of 300 tons can pass along all the main lines of inland waterways in France; whilst along the Lower Seine, and a few of the waterways connected with it, converging to Paris, still larger vessels can be accommodated.

Development of Belgian Waterways.—Great interest has been manifested by the Government of Belgium in the improvement of its waterways. The Ghent-Terneuzen canal has been enlarged, a ship-canal to Bruges is about to be carried out, and various lines of water-communication have been formed, improved, or extended. The most interesting recent work, however, in relation to the subject of this paper, is the canal which will place Mons in direct connexion by water with Brussels, Charleroi, and Liége, and by a junction with the Mons and Condé canal at Mons, will provide communication by water with the Scheldt, and thereby with the network of waterways intersecting the northern corner of France. This canal du Centre, 13 miles in length, and running in places alongside the Mons and Namur railway, forms a very important link in the waterways of the flourishing mineral districts of Belgium; and it has already been completed up to Thieu, a distance of about 9 miles from Mons, with a rise of 76 feet, accomplished by locks provided with side ponds to economize water.

Hydraulic Canal-lifts in Belgium and France.—The difficult part of the canal du Centre is comprised in the 4⅓ miles between Thieu and the junction of the canal at La Louvière with the Charleroi and Brussels canal, in which a rise of 217 feet has to be surmounted, and water is scarce. These impediments for a long time prevented this important line of communication in the coal-and-iron districts of Belgium from being undertaken. They are, however, being overcome by the erection of four large hydraulic canal-lifts, with counterbalancing caissons, like the lifts at Anderton on the Weaver, whereby vessels of 400 tons, floating in water, can be raised or lowered 50½ to 55½ feet in 2½ minutes, with an expenditure of only 270 cubic yards of water for each operation. One of these lifts was erected at La Louvière as a test of the system; and as it was proved to work satisfactorily, the three others are being constructed. A similar lift for raising vessels of 300 tons a height of 43 feet, was opened for traffic in 1888, at Fontinettes near St. Omer, on the Neuffossé canal, connecting the port of Dunkirk with the mineral districts of Belgium, owing to a flight of five locks having become quite inadequate to cope with the greatly increased traffic resulting from the enlargement of these waterways.

Locks with Large Rises, Deep Sills, and Cylindrical Sluice-gates.—Long delays at numerous locks offer a serious impediment to inland navigation, and greatly diminish the capacity of a waterway for the transit of vessels. The time, accordingly, occupied in the passage through locks has been greatly reduced within recent years in France, on altering the locks to conform with the standard dimensions: in the first place, by reducing the number of the locks and increasing their rise, which has the farther advantage of increasing the length of the reaches between the locks, and diminishing the fluctuation in their water-level due to lockings. This plan has been systematically carried out on the canal du Centre, the Scheldt-Maas canal, and the St. Denis canal; and on the latter canal, one of the new locks, 205 feet long, 27 feet wide, and with 10½ feet depth of water on the sills, capable of admitting the largest vessels navigating the Lower Seine, has been given a rise of 32½ feet, four times the original rise of the locks, thereby enabling three locks to be suppressed.

In most cases also, in the reconstruction of the locks, the sills have been placed lower than required for the actual draught of the vessels, so that the entrance and exit of large vessels are facilitated by their immersed section not approximating too closely to the sectional area of the waterway in the lock. The outflow, moreover, of the surplus water displaced by a vessel on entering a lock, or the inflow on its leaving, is farther facilitated by numerous openings in the side-walls of the lock, communicating with longitudinal sluice-ways.

The filling also and emptying of the lock-chamber, in the process of locking, are much expedited by the longitudinal sluice-ways and side outlets, especially when the influx and efflux are controlled by large counterbalanced, cylindrical sluice-gates, like those adopted on the Weaver in 1878, which are very readily raised or lowered owing to the pressure being uniform all round them. For instance, the lock with the large rise of 32½ feet on the St. Denis canal, is filled or emptied in eight minutes; while the large lower lock-gate is opened or closed in one minute by hydraulic power, and the cylindrical sluice-gates are raised or lowered to their full extent in a few seconds.

Distribution of Traffic on French Waterways.—The uniformity in gauge of the main lines of French waterways has been so recently effected that the full advantage of this very important improvement has not had time to manifest itself; whilst several large connecting-lines are still in course of construction, and some modifications in existing lines have not yet been carried out. Accordingly, it is too early as yet to judge of the influence which the uniformity in the waterways may have upon the development of inland navigation in France, though more than 2,500 miles of rivers and canals have now the standard depth and size of locks, as compared with only 900 miles in 1878. In most cases, indeed, an improvement in traffic has already resulted from an improvement in the waterway; but it would be a most grievous error to assume that uniformity in size will ever lead to uniformity in traffic. A glance at the map published annually by the French Ministry of Public Works, in which the traffic on the several waterways is indicated by the width of a blue band along them, would at once dispel any such illusion. The main bulk of the traffic along inland waterways in France is confined to the Seine between Montereau, above Paris, and Rouen (the limit of ocean-going navigation), and more especially to the northern waterways connecting the coal-fields and centres of iron industry in Belgium with Paris and Dunkirk.

Inland Waterways in England with a Large Traffic.—According to the Board of Trade returns for 1888, the Birmingham canal navigations convey by far the greatest tonnage of all the inland waterways of Great Britain, amounting to 7,713,000 tons in the year, more than two and a half times the traffic of the Bridgewater canals, with 2,917,000 tons. Next comes the Aire and Calder navigation, with its large coal traffic, carrying 2,211,000 tons; after which follows the Leeds and Liverpool canal, with a tonnage of 2,017,000 tons. The waterways which have a traffic of over one million tons a year are the Regent's canal with 1,673,000 tons, the Weaver navigation with 1,498,000 tons, the Forth and Clyde navigation with 1,257,000 tons, the Grand Junction canal with 1,172,000 tons, the Trent and Mersey navigation with 1,139,000 tons, and the Shropshire Union canals with 1,125,000 tons.* The most profitable of these undertakings is the Regent's canal, with a length of only 10¾ miles, and a net revenue of £4,228 per mile, owing to its exceptional position in the middle of London. The most remunerative, however, of the regular waterways of considerable length is the Aire and Calder navigation, 93 miles long, which yields a net yearly revenue of £1,213 per mile. The position of this undertaking, and its financial prosperity are undoubtedly due to the company having repeatedly improved its depth and increased the size of its locks, to meet the growth and requirements of traffic, which has enabled it to maintain a very profitable competition with railways in the carriage of bulky goods. The Bridgewater canals come next, with a length of 75⅓ miles, and a revenue of £895 per mile, serving important industrial districts of Cheshire and Lancashire; whilst the Weaver navigation follows after, with a length of only 20 miles, but with a revenue of £807 per mile, owing to its large traffic of salt from the salt-mines round Northwich; and then come the Birmingham canal navigations, nearly 159 miles in length, and yielding a net yearly income of £731 per mile, about double the return of the Grand Junction and Leeds and Liverpool canals, and still more in excess of the Trent and Mersey navigation. The above instances, and others that might be cited, such as the Rochdale canal and the Don navigation, show that a large traffic and good returns are obtained on those inland waterways of England which connect important industrial and mineral districts with seaports, where large quantities of bulky goods have to be conveyed, in spite of the serious hindrances which result from a want of uniformity in gauge in through routes, and the neglect shown in most cases to develop the capabilities of the waterways in accordance with modern requirements. Those waterways, indeed, have been most successful which, possessing a traffic in bulky goods, have been able, from their position, to secure uniformity of gauge from the districts they serve to the terminal seaport, and have also been improved in depth and size of locks to meet the growing exigencies of trade, such as the Aire and Calder navigation, the Weaver navigation, and the Bridgewater canals. The large traffic along the Birmingham canals, and the goods traffic along the Worcester and Birmingham, the Warwick and Birmingham, and the Warwick and Napton canals in proportion to their lengths, notwithstanding the small width of their locks, can only be attributed to the remarkable suitability of the goods for conveyance by water; and the accommodation and development of this traffic are deserving of far more consideration than has hitherto been paid to them.

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* The proper basis of comparison of traffic along any route is the number of tons carried one mile, or the ton-mile; but, unfortunately, the Board of Trade returns, unlike the French returns, do not afford this information.

Conditions favourable to the Improvement of Inland Waterways.—The foregoing particulars show that the traffic along waterways can be considerably expedited by the use of hydraulic lifts where the change of level is great, or by a smaller number of enlarged locks, with a large rise and improved appliances, where the slope of the ground is more moderate. It is also well known that a large traffic is conducted more economically and expeditiously along a large waterway. It has, moreover, been amply proved by statistics that those waterways attract the largest traffic which connect mineral districts with large towns and seaports, and that they are most prosperous when they possess uniformity of gauge, and are gradually improved to meet the growing requirements of navigation.

Birmingham, with its surrounding mineral districts, is manifestly peculiarly well-adapted for providing a large traffic along inland waterways connecting it with a seaport, for shipping its goods to foreign ports; for the inland waterways in communication with it have developed a large traffic, in spite of their inadequate size, their want of uniformity in gauge, and the diversity of their control. If the French Government considers that it is essential to continually improve the water-communication with the mineral districts of Belgium, and the Belgian Government considers it expedient to construct a new canal, capable of accommodating vessels of 400 tons, under unfavourable physical conditions, in order to improve the communications of the mineral districts of Belgium, it is surely time for Birmingham to secure access to a seaport by a waterway capable of admitting vessels of a larger carrying capacity than 50 tons. British trade cannot be expected to maintain its supremacy for long if no effort is made to afford its inland industrial districts the same facilities for water-carriage as are readily provided by foreign governments for similarly situated centres of trade. Many of the inland waterways in England have succumbed to the competition of railways, partly owing to neglect of timely development, partly to the want of suitable traffic, and partly to the proximity of so many places to tidal rivers or the sea. Birmingham, however, is situated a long distance inland; and therefore its position, and the nature of its trade, mark it out as one of the chief districts in England which should long ago have obtained a commodious waterway to a seaport, with great advantage to its trade, and with financial benefits to the undertaking itself.

Position of Birmingham, and Possible Routes to the Sea.—Birmingham is situated in the basin of the Trent; but it is so near the boundary between this basin and that of the Severn, that it is at an elevation of about 350 to 450 feet above mean sea-level. Most large towns are situated so definitely within the valley of a river that their natural route to the sea is along that valley. The situation, however, of Birmingham in relation to the Trent, and its central position in England, afford it three or four possible routes by water to the sea. The natural fall of the land is by the valleys of the Cole and the Tame into the Trent; and it is also physically possible to obtain access from Birmingham by water to the Mersey, the Severn, the Thames, and by the Nene to the Wash; and, indeed, in a map (Plate XXV.) of the canals and navigable rivers of England,* a continuous waterway is indicated between Birmingham and all these rivers. Though the Trent valley at first sight appears to form the natural outlet for Birmingham by water, the existing route by which the Trent is reached is circuitous, passing along one of the Birmingham canals, part of the Coventry canal, and part of the Trent and Mersey canal, before reaching the Trent navigation near the confluence of the Derwent. The distance between Birmingham and Gainsborough by this route is 115 miles, or 136 miles to the Humber; the total variation in level is 461 feet, surmounted by 74 locks; and the largest barge that can navigate the whole length is 71 feet long, 6 feet 10 inches broad, and drawing 2½ feet of water. The objections to this route appear to be the four different ownerships of the waterways traversed (two being controlled by railway companies), the totally inadequate width and depth of a great portion of this long route, and its divergence from the natural lines of Birmingham trade with foreign ports.

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* *Map of Canals and Navigable Rivers of England and Wales.* By Mr. L. B. Wells.

The route by the Nene to the Wash need not be taken into consideration, for the navigation of the river between its junction with the Grand Junction canal and Peterborough, appears to have fallen into decay; and if it is expedient to adopt this route as far as the Nene, it would be much better to continue along the Grand Junction canal to the Thames.

The three remaining routes, to the Mersey, the Thames, and the Severn respectively, are those for which schemes for an improved waterway between Birmingham and the sea have been proposed. In order to facilitate a comparison of these routes, both as regards the general variations in level, and the length of waterway to be improved or constructed, longitudinal sections are given of them, taken from published accounts of the three schemes, reduced to uniform scales (Plate XXVI.)*

The height of Birmingham above sea-level, and its distance by the nearest possible route from the point on any tidal river up to which ocean-going steamers can ascend, preclude the possibility of connecting it with the sea by means of a regular ship-canal, at any reasonable cost, even if the experience of the Manchester ship-canal had proved favourable financially to such undertakings. The rise to Birmingham, indeed, from sea-level is five times the rise to Manchester, and the distance of Birmingham from its nearest tidal port at Sharpness, on the Severn estuary, is more than double the distance of Manchester from Eastham. Accordingly no serious proposal has been made for constructing a ship-canal for ocean-going vessels to Birmingham, though two of the schemes for an improved waterway have received the ambitious, and somewhat misleading, title of ship-canal.

Birmingham to Liverpool by Water.—As Birmingham is near the southern part of the ridge which separates the basin of the Trent from that of the Severn, and this dividing-line runs for about 35 miles in a north-westerly direction before reaching the Mersey basin, any canal from Birmingham must skirt along near the high ground of this tortuous ridge, or in adopting a straighter course, must descend somewhat into the Trent or Severn valley before rising again to surmount the boundary of the Mersey basin. Accordingly, in adopting this route, a greater difference in level has to be overcome than the mere elevation of Birmingham above sea-level.

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* *Report on Improving the Water-communication between London and Birmingham.* By Mr. H. J. Marten, 1886; "The Birmingham and Gloucester Ship-canal," *The Engineer*, 1887 (1), page 499, and 1894 (1), page 471; "The Birmingham and Liverpool ship-canal," *The Engineer*, 1890 (2), page 247.

The existing route by water from Birmingham to the Mersey estuary, and thence to Liverpool, is by the Birmingham and Wolverhampton canal, past Wolverhampton, to the Staffordshire and Worcestershire canal at Autherley, of which only a very short portion is traversed before entering the Birmingham and Liverpool canal, which extends to Nantwich. From this town the route is continued along the Chester canal to Chester, and then by the Wirral line of the Ellesmere canal to Ellesmere Port, formerly on the Mersey estuary and now on the Manchester ship-canal. The waterways traversed after leaving the Staffordshire and Worcestershire canal, up to Ellesmere Port, form part of the system of the Shropshire Union canals, so that this route is owned by three independent companies. The total length of this route, between Birmingham and Ellesmere Port, is about 85 miles; and owing to a rise before reaching Wolverhampton, and a subsequent dip into the Severn valley before reaching the Mersey basin, the total variation in level reaches 585 feet, which is surmounted by eighty-five locks; and, moreover, two short tunnels are traversed. The largest barges that can navigate this route are 71½ feet long, 6¾ feet wide, and 3¼ feet draught.

The line for a canal from Birmingham to the Mersey, proposed in 1890 by the late Sir James Brunlees and Mr. McKerrow, only followed the above route approximately as far as Wolverhampton.* From this point it took a northerly direction, past Penkridge and Stafford, in the valley of the Penk, to Stone, where it entered the upper valley of the Trent, and continued to Stoke. Thence it turned in a north-westerly direction, and running approximately parallel to the Trent and Mersey canal, it passed Tunstall, then crossing from the Trent to the Mersey basin at Harecastle, it went on past Kidsgrove and Wheelock to Winsford, where, after a course of 63¾ miles, it was to join the Weaver navigation, 20 miles from the junction of this navigation with the Manchester ship-canal. The canal was designed to have a bottom width of 50 feet, for conveying vessels of 300 to 400 tons, it being proposed to effect the changes in level between the reaches by means of hydraulic lifts, similar to those of Fontinettes and La Louvière. The longitudinal section (Fig. 1, Plate XXVI.) shows that the canal was to commence at Birmingham, at a height of 387 feet above mean sea-level, rising by two lifts to a summit-level of 472¾ feet about 3 miles short of Wolverhampton, and then descending by four lifts, between Wolverhampton and the crossing of Watling Street, into the valley of the Penk, to 296 feet above sea-level, which level was to be continued into the upper Trent valley, past Penkridge, Stafford, and Stone, to Trentham, for a length of 21 miles. Then it had to rise again by four lifts to another summit-level, 460 feet above the sea, in order to pass at Harecastle across the ridge between the Trent and Mersey basins, descending from this point by eight lifts to the Weaver at Winsford, 54½ feet above the sea. The total variation in level, accordingly, by this route would be 832 feet, proposed to be surmounted by eighteen lifts, with rises varying between 19¼ and 66½ feet, and averaging 46 feet.

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* *Engineering*, 1890 (2), page 372, and *The Engineer*, 1890 (2), page 247.

This scheme would undoubtedly provide a waterway for Birmingham to the sea, quite on a level with the largest inland canals on the Continent; and the proposed system of lifts would enable the great changes of level to be rapidly accomplished with a small expenditure of water. This canal, however, would be a very costly work, being estimated by its promoters at £5,000,000. There was also some reference made in the description of the proposal, to possible settlement in the mining districts; but any settlement in the foundations of the hydraulic presses of the lifts would be fatal to their efficient working. Moreover, the tendency to such settlement is increased, in the case of the slightest instability of the foundations, by the repeated shocks to which the presses are exposed in the process of lifting the troughs. The scheme, moreover, by following the route of a portion of the Birmingham canals as far as Wolverhampton, would naturally be strongly opposed by the London and North-Western Railway Company which appears to control these canals, and also by the Shropshire Union Railway and Canal Company, whose traffic from the Birmingham canals to the Mersey it would tend to divert. The canal by passing through the district of the Potteries, would have the prospect of obtaining another class of goods traffic very suitable for waterways; but it would at the same time come into direct competition with the Trent and Mersey canal, and consequently with the North Staffordshire Railway Company, and might possibly be forced to buy up the Trent and Mersey canal, as the Manchester Ship-canal Company had to buy up the Bridgewater canal. Such an outlet for vessels of 300 to 400 tons from Birmingham to the sea, when once accomplished, would undoubtedly prove of great value to the trade of Birmingham; but the difficulties attending this route, and the very expensive character of the works through unfavourable country, seem to render it expedient to try and select some other route less certain to arouse serious opposition, and which might be obtained at a smaller cost.

Birmingham to London by Water.—When canals were being extended throughout England, it was natural that Birmingham should be connected by water with London. The configuration, however, of the intervening country is not favourable for such a waterway; for a portion of the Severn basin separates the Trent basin from the Thames basin, and the principal waterway between Birmingham and London crosses the basins of the Severn, the Nene, and the Ouse, before entering the Thames basin, involving considerable variations in level. By the Oxford canal, indeed, the waterway merely traverses the Severn basin in passing from the Trent basin to the Thames basin, and the river Thames is joined at Oxford; so that by this route the number of locks is less by one-third than by the Grand Junction canal; but this latter canal provides wider locks and a greater available depth, as well as a shorter course owing to the windings of the Thames.

The chief route, accordingly, from Birmingham to London by water, and the one which it has been proposed to improve, is along the Warwick and Birmingham canal to Warwick, then by the Warwick and Napton canal to Napton, where the Oxford canal is traversed for about 5 miles before reaching the Grand Junction canal which continues the waterway to its junction with the Thames at Brentford. The proposed improved longitudinal section of this route, between Birmingham and Brentford* (Fig. 2, Plate XXVI.), shows the considerable variations in level of the waterway in going across the basins of the Severn, the Nene, and the Ouse, whose water-partings are traversed in tunnels at Braunston and Blisworth, and in a cutting at Tring on the boundary of the Thames basin. The greatest dip occurs in crossing the valley of the Avon in the Severn basin, at a level of 180 feet above the sea; and the greatest elevation is attained at Tring, 393 feet above the sea, before descending finally to join the tidal Thames. The length of this waterway between Birmingham and Brentford, at the present time, is 135 miles; and the total variation in level along the route reaches 1,088 feet, which is surmounted by one hundred and sixty-one locks.†

The improvement of this route was recommended by the late Mr. H. J. Marten, in a report to a committee of the Birmingham Corporation, in 1886, which was approved by the committee.‡ At the present time only vessels 70 feet long, 7 feet wide, and 3¾ feet draught, carrying 30 tons, can pass through the locks of the Warwick and Birmingham and Warwick and Napton canals; and though the locks on the Grand Junction canal can accommodate vessels 70 feet long, 14 feet wide, and 4 feet draught, carrying 80 tons, the depth of the canal is inadequate to pass barges loaded with more than 50 tons. It was proposed to enlarge the waterway throughout to a bottom-width of 21 feet and a depth of 8 feet, and to make the locks 160 feet long, 14½ feet wide, and with a depth of 7 feet of water on the sills, so as to admit a tug-boat holding 60 tons of cargo at the same time as a barge of 80 tons, or a steamboat 120 feet long, 12 feet wide, and 6 feet draught, carrying 130 to 140 tons. The locks were to be reduced to ninety in number, and their rise increased in some cases to 27½ feet; and it was estimated that the time of transit would be reduced by twelve hours. The cost of the improvement-works was estimated at £1,250,000.

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* *Report on Improving the Water-communication between London and Birmingham.* By Mr. H. J. Marten, 1886.

† *Returns made to the Board of Trade in respect of the Canals and Navigations in the United Kingdom for the Year* 1888.

‡ *Report on Improving the Water-communication between London and Birmingham.* By Mr. H. J. Marten, 1886.

A good communication by water between Birmingham and London would be very advantageous, as, besides giving Birmingham access to the largest seaport of Great Britain, it would also promote the trade between Birmingham and the capital. The physical features of the country, however, are decidedly unfavourable for such a connexion; the route is very long; it would necessitate very extensive and costly improvements along the canals of four independent companies; and the great variations in level would render the working expensive, the passage of vessels relatively slower, and the expenditure of water very considerable for a large traffic. The widths proposed for the enlarged waterway, and for the locks, appear somewhat small, though the depth provided is ample; and it might be well to increase these widths to the standard dimensions of the main lines of waterways in France, and thereby provide for vessels of between 200 and 300 tons. Where the changes in level are abrupt, hydraulic lifts would economize both time and water. These suggested modifications would doubtless raise the cost, which, as proposed, is already considerable, considering the small increase in the tonnage of the vessels provided for; but it is essential in any scheme that provision should be made for vessels of the size suited to the requirements of inland navigation in the present day.

Birmingham to the Severn by Water.—As Birmingham is close to the south-western edge of the ridge separating the basins of the Trent and the Severn, it is possible to carry a waterway into the Severn basin in this direction by merely piercing the crest of the ridge by a tunnel, as effected by the Worcester and Birmingham canal, without any rise. The descent from this ridge to the Severn is undoubtedly rapid; but there is some advantage in having the unavoidable descent from Birmingham to the sea somewhat concentrated, as by the adoption of lifts or inclined planes under such conditions, a considerable change in level between the reaches can be rapidly effected.

Birmingham is connected with the Severn at Worcester by the Worcester and Birmingham canal, from which town the Severn has recently been rendered navigable by vessels of 400 tons down to Gloucester; and thence, by the Gloucester and Berkeley canal, access is obtained to the Bristol Channel. The Worcester and Birmingham canal passes in a level reach from Birmingham to Tardebigge, a distance of 13½ miles, passing through four tunnels before commencing its descent of 425 feet to the Severn at Worcester, as shown by the longitudinal section of the existing canal (Fig. 3, Plate XXVI.). The first 217 feet of the descent are effected by a chain of twenty-nine locks at Tardebigge, followed by a chain of six locks at Stoke Prior descending 42 feet; and after a level reach of about a mile, a farther descent of 42 feet is accomplished by another chain of six locks at Dodderhill, which is separated from a third chain of six locks at Tibberton, by a level reach of about 5½ miles, passing through a very short tunnel. The remainder of the descent of 82 feet is effected by ten locks, making the total number of locks fifty-seven. The length of the canal is 30 miles; and barges 71½ feet long, 7 feet wide, and 4 feet draught, can pass along it.

The improvement of this canal to accommodate vessels of 200 to 250 tons was proposed by Mr. Keeling in 1887, by widening the canal at the top from 33 feet to 66 feet, and increasing its depth from 5½ feet to 9 feet, and by constructing thirteen locks, from 110 to 210 feet long, 20 feet wide, and 8 feet deep, with a rise of about 14 feet, and an incline in place of the existing locks at the Tardebigge flight.* The cost of this work was estimated at £600,000. Mr. Keeling would prefer adopting the route by Droitwich, joining the Severn above Worcester, which would shorten the canal-route by two miles, concentrate the locks, and avoid the Dunhampstead tunnel; but it would involve raising Worcester Bridge, enlarging a lock above Worcester, and dredging in the Severn, to enable the proposed class of vessels to pass along the Severn above Worcester to the entrance of the Droitwich canal. The great merits of this route are the moderate length of canal that would require improvement before reaching a waterway of adequate size, the undivided ownership of the canal needing enlargement, and the absence of variations in level beyond the necessary descent from Birmingham to sea-level. It appears expedient to make the enlarged waterway available for the same sized vessels up to Birmingham, as those that can at present ascend the Severn up to Worcester; and it is possible that lifts might advantageously replace locks where grouped together, and be employed at Tardebigge instead of an incline. It seems also advisable to defer the proposed extension of the Gloucester and Berkeley canal to Sheperdine, till the improvement of the Worcester and Birmingham canal has been carried out, unless it is treated as quite a separate undertaking; for the enlargement of the canal is a matter of inland navigation, whereas the extension to Sheperdine is for sea-going vessels, which may become a necessity for Gloucester, in the event of its inland trade with Birmingham becoming largely developed by the enlarged waterway.

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* *The Engineer*, 1887 (1), page 499, and 1894 (1), page 471.

Comparison of Inland Waterways for Birmingham.—A comparison of the three longitudinal sections (Plate XXVI.) illustrates very forcibly the difference in the physical conditions of the three routes. The route to the Thames involves the improvement of 132½ miles of waterway, with successive dips and rises, and consequently numerous locks. The route to the Weaver is 63¾ miles long, only about half the distance to the Thames, but involving an entirely new canal with rises and falls. The route to the Severn is only 28 to 30 miles in length, less than half the distance to the Weaver, and less than one-fourth the distance to the Thames; it merely involves the improvement of a single canal, with no greater variation in level than that imposed by the elevation of Birmingham. From an engineering point of view, accordingly, the Severn route is much the best, simply on account of the shorter distance, and more favourable physical conditions of the intervening country.

The development of a waterway to the Thames would necessitate arrangements with four independent companies; the proposed route to the Weaver would be sure to arouse vehement opposition, and competition with three railway companies; whilst the route to the Severn would be concerned with only one company. Accordingly, in this respect the improvement of the waterway to the Severn would be much easier to arrange; though probably none of the four canal companies on the Thames route would be in the least averse to the enlargement of their waterways.

The proposed new canal to the Weaver would have the advantage of accommodating other districts on its route, to the north of Birmingham; whereas the routes to the Thames and Severn would only give direct accommodation to Birmingham. It has also been stated in favour of this new canal, that 43 per cent. of the sea-borne traffic of Birmingham is shipped at Liverpool; whilst judging from the traffic on the Warwick and Birmingham, and Worcester and Birmingham canals, amounting to 353,100 and 392,600 tons respectively in 1888, the traffic which goes southwards from Birmingham by inland waterways is fairly evenly divided between the existing Thames and Severn routes, though slightly in favour of the latter. Whatever advantages, however, may be possessed by the route to the Weaver in these respects, appears to be outweighed by its great cost and prospects of opposition.

Gloucester, indeed, is by no means on an equality with London or Liverpool, either as a commodious seaport for the foreign trade of Birmingham, or as a market for its goods; and other conditions apart, London or Liverpool would naturally be preferred, though it must not be overlooked that the route by Gloucester gives easy access to Bristol, Newport, Cardiff, and Swansea. The waterway to the Severn, however, even now appears to attract a little more traffic than the waterway to the Thames; and unless some serious commercial impediment should exist to the development of the waterway to the Severn, and the adoption of Gloucester, Sharpness, or Sheperdine as the seaport of Birmingham, the paramount conditions of cost and shortness of route plainly indicate the route to the Severn as the proper outlet for the water-borne trade of Birmingham. In the face of the financial condition of the Manchester ship-canal, it would be useless to propose the execution of the proposed new canal from Birmingham to the Weaver, with an estimated expenditure of £5,000,000, which would doubtless be exceeded. The route to the Thames appears to have been favourably regarded by the Birmingham corporation, and the scheme of improvement is desirable enough in itself; but the enlargement proposed is scarcely adequate to the present requirements of inland navigation. Moreover, to provide a waterway from Birmingham to the Thames, suitable for vessels of 300 to 400 tons, along a distance of 132 miles, would cost considerably more than double the formation of a similar waterway to the Severn along a length of only 30 miles. Owing, indeed, to considerations of expense, the choice probably lies between the adoption of the Severn route and the abandonment of a much-needed enlarged waterway between Birmingham and a seaport. The writer is, therefore, of opinion that it is very expedient for the Birmingham corporation and all others who are interested in improving the access of Birmingham by water to the sea, to investigate fully the best means, and the cost, of connecting Birmingham with the Severn by a waterway capable of accommodating vessels of 300 to 400

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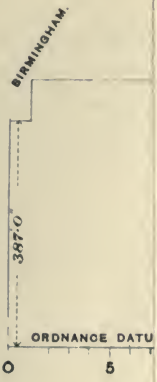

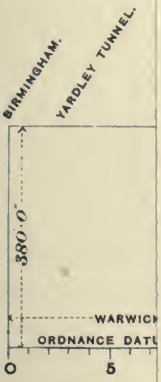

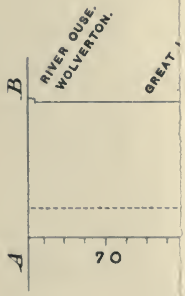

tons, along the route at present traversed by the Worcester and Birmingham canal, as affording a prospect of obtaining the cheapest, shortest, and most feasible outlet for the water-borne trade of Birmingham, in a direction well suited for transit to foreign ports.

The following paper by Mr. W. Salt, on "Canals and their Improvements," etc., was taken as read :—

CANALS AND THEIR IMPROVEMENTS, MORE PARTICULARLY APPLYING TO THE LONDON AND BIRMINGHAM TRADE.

BY W. SALT.

Canals in the latter part of the last and in the earlier part of this century were without doubt of the greatest importance to the welfare of this country. As a means of transport they came largely into use in this country at the end of the last century, and although they were then very efficient methods of conveyance, they have, with one or two solitary exceptions, failed to keep pace with the necessities of the age. This fact is made very obvious by some of the antiquated pumping-engines to be seen at some of the old canal works. There is one in Birmingham in the original state in which it was left by Messrs. Boulton & Watt in the year 1796. Canals are practically in the same condition, and they are even as the machines of a hundred years ago, with absolutely no improvement.

A farther defect of the canal-systems in this country is the utter disregard of uniformity displayed in their construction. There appears to have been practically no idea of transferring traffic from one canal to another. Each company made its canal with regard only to local interests, and in several instances the sizes of locks have varied two or three times upon the same line of navigation, efforts being made to cultivate a local trade only.

During the railway mania there was hardly a canal in the kingdom which did not seek either to ally itself with some railway enterprize or sell itself outright for conversion. The railways have obtained the control of many of the chief links in the canal-system, and they now hamper and obstruct any attempt at making either working rates or tolls. Even where they do not use their utmost endeavour to cripple the trade upon the canal, and drive it on to their railways, they make canals almost a dead letter for any through trade from want of repair. A further result of the alliance with railways is that no improvement of any kind has been undertaken by any independent canal company.

Canals have now, the writer believes, reached a very critical period in their history, and unless some large and comprehensive scheme be devised for the consolidation of the main navigation-routes, with a view to their immediate improvement, the time is not very far distant when they will be unable to resist the encroachments of their more powerful competitors, and they, like a number of their less fortunate neighbours, must become derelict. That this was felt to be the case the investigation of a Joint Committee of the Houses of Lords and Commons, which sat in 1872, fully evidences, for in their report they recommend:—

(1) That no inland navigation now in the hands of a public trust shall be transferred to or placed under the control of a railway company, and that if the trustees of an inland navigation or a canal company apply to Parliament for power to purchase compulsorily a canal from a railway company, such purchase shall be favourably considered by Parliament.

(2) That the utmost facilities shall be given for the amalgamation of the adjoining canals with one another, or with an adjoining navigation.

The first step appears to be clearly the amalgamation of so many of the existing companies as are owners of links of a through route, or of any collateral canals between a large producing and consuming district, and the nearest importing and exporting port; and, in the writer's opinion, the larger and more comprehensive the area included in such a scheme the better is the prospect of efficiently competing with the railways. In fact were the whole of the canals south of Liverpool, inclusive of the Trent and Mersey canals, grouped in one scheme, and those of the remaining northern canals in another, there would be far better chances of success, and of making their influence felt in rivalry with the railway companies.

Much has been said of the manner in which such an amalgamation should take effect, whether the whole of the canals should be taken over by the State, or whether it should assume the form of one of the statutory companies as at present constituted, or whether, again, the amalgamation should be in the nature of a public trust administered for the benefit of the various counties or districts through which the canal passes. The former scheme has much to recommend it, but it is very questionable whether a State department can be worked as efficiently as a private enterprize. As to the suggestion of a public trust, the writer thinks that no satisfactory method has yet been suggested, either of raising the necessary capital, or of dividing the proceeds.

The most satisfactory section for an inland canal has yet to be settled, as the requirements of different districts vary so considerably. Unquestionably a large sectional area is desirable for economical traction, but it is questionable whether the desire for large sections is not carried too far. If canals are to compete successfully with railways and become a public benefit, they must not be hampered with too much capital. The expenditure upon improvements should be gradual, and continued from time to time as the requirements of the traffic demand. Mr. Saner gives the sectional area of canals as varying from 130 square feet for the narrow canal to 780 square feet for the Weaver navigation. The narrow canal is, however, what we are most concerned about, for while several have locks capable of passing boats of a width of 14 feet, the cross-section of the waterway would not admit of the passing of two boats on the main lines of the canal, and consequently they must be considered as narrow.

The writer conceives that improvement should proceed somewhat on these lines, viz. :—

(1) Improvement of the sectional area of the waterway.
(2) Improvement of the capacity of the locks.
(3) Traction.

(1) There are few canals that would not admit of dredging to a depth of 5½ to 6 feet, and where the width is small, they might be walled on either side to the full depth of the canal, thus increasing their sectional area and providing the best safeguard against damage from the wash of the water. With such a depth, boats 70 feet long and 7 feet beam could be readily built to carry 40 tons. This size of craft has many unquestionable advantages: It is handy in every sense of the word, there being very few manufacturers who can give more than 40 tons in one consignment, except of low-class articles, such as coals, bricks, roadstones, etc., and even then the 40 tons load has advantages in distribution which the larger boat does not possess. The traction of the small boat is not appreciably greater per ton than that of a barge, and in many instances it is much less. With a canal having an available depth of 5½ feet, a train of eight 40 tons boats could be satisfactorily towed at a cost of 0·10d. per ton per mile. Mr. Wells gives the cost of traction on the Aire and Calder canal for goods at 0·03d. per ton per mile, but this is only attained on a river navigation of such a sectional area as would (in the writer's opinion) enormously increase the capital cost of canals if they were brought up to that standard, and entirely destroy all hope of successful competition for many years. On the Bridgewater navigation, four barges laden with 60 tons each can be hauled at a cost of

0·10d. per ton per mile. Taking these figures, the cost of transport of bricks or coal between South Staffordshire and London, a distance of 150 miles, would be 1s. 3d., to which might be added an improved toll of say 3s. 6d., making a total charge of 4s. 9d., as against the railway rate of 6s. 6d., which at present is charged. As a matter of fact the toll on bricks to London at the present time is less than that stated by Mr. Wells, and the cost of haulage by horse-power is not less than 0·44d. per ton per mile.

(2) Although a very large traffic may be carried upon the narrow canals in small boats, steam traction cannot be applied satisfactorily with the present small locks. To successfully cope with this difficulty, the writer is of opinion that locks of a capacity of not less than nine boats, including the tug, should be contemplated. The dimensions of such a lock would be roughly 220 feet long, 22 feet wide, and have a fall of about 21 feet; and for the economizing of water the locks might be made double. To prevent loss of water when smaller trains of boats than nine were passing, gates might be placed so as to take either three or six boats at once. Of course it will be said that locks are wasteful of water, and that this waste must be made up by pumping; but there is this advantage over a mechanical arrangement, that in times of large rainfall no cost is incurred in supply. Locks are infinitely less likely to be stopped by any defect in the arrangements for their working than are hydraulic lifts or inclined planes. They are less costly to construct and no skilled labour is required to work them. They can be worked as expeditiously (or more so) than any mechanical appliance.

The writer some years ago interested himself largely with what he considered the best form of lift, and for simplicity of working he thought that was the hydro-pneumatic type. But although he gave considerable attention to this and other forms of lifts, he came unhesitatingly to the conclusion that no cheaper form could be adopted than that of a modification of the present double lock, with a suitable pump to raise the lockage water. An efficient pump will raise 1,000,000 gallons of water 100 feet high for 20s. Now, assuming for the traffic from South Staffordshire to London or *vice versa* that water had to be raised by pumps to an aggregate height of 900 feet (and this would, in the writer's opinion, be more than would be required, the water for the supply at the present time not being raised one quarter of that height, the balance being obtained from gravitation-supplies), this would give an expenditure for pumping water for the whole journey to London of about 4d. per ton, and if double locks were used the cost would be 2d. per ton of cargo, or

3d. per ton of cargo, assuming that half of the boats returned empty. Assuming also that 30 hydraulic lifts could be made to take the place of the proposed locks (which is doubtful), and that they could be worked at the cost which Mr. Saner allocates to the Anderton lift if in full work, viz., 0·20d. per ton, this would represent 6d. per ton for lifts to London; the probable figures would be nearer 1s. 3d. per ton, as against 3d. per ton, the cost of pumping.

Such a lock would be capable of working three boats of 21 feet beam and 70 feet long, or three barges of 14 feet beam and three boats of 7 feet beam, or nine boats of 7 feet beam. With moderate dredging, the alteration of ten or twelve bridges and this lock, 14 feet barges could be navigated from Staffordshire to London. For large boats, the reconstruction of the whole of the canals on the route would be involved. The smaller craft and the barge would afford greater facility for larger packages, machinery, boilers, etc., than is offered by any of the railways carrying such goods.

The cost of such an improvement would be moderate as compared with the cost per mile of railways. It would entail no purchase of lands other than that for the new locks. The cost of working such a canal would probably not exceed that of working the present canals except for water, and this would be proportionate to the traffic passed.

(3) Although the method of traction referred to in this paper has been that by means of a steam-tug, it would seem that there is a very large future for the use of motors taking the form of oil or electric engines for propelling the boats, or of oil or electric locomotives for hauling them. That a satisfactory locomotive could be built upon either of these lines which would pass under most of the existing bridges appears to be hardly open to question. As to the latter form of locomotive, canals are particularly adapted for the overhead trolley electrical system.

Mr. Vernon-Harcourt appears to advocate the making of the canal from Birmingham to Worcester of such capacity as would enable boats of some 200 or 300 tons to navigate from the Bristol Channel to Birmingham. Whilst the writer would personally hail with pleasure any improvement of the existing water communication with Birmingham, he cannot lose sight of the fact that London and Liverpool (to which might be added Manchester) are essentially the ports of import and export of the kingdom, and that practically all the merchants are centred at these three places. It would be a hazardous experiment to try and divert the trade from either. A moderate scheme of improvement would no doubt very largely enhance their trade. There has been for a number of years past, vastly more loading for boats in London for distribution in the provinces than there have been boats to take it away. The great difficulty encountered by the canal carriers is to get paying loads to London, as the large amount of traffic from Birmingham and South Staffordshire is largely absorbed by the railways at very low rates. London and Liverpool therefore appear to be the ports to which any improvements in the canal-routes should be directed. The improvement of the collateral connexions could be effected as the exigencies of the trade required.

The first step, however, is to amalgamate the whole of the existing independent canal companies between certain given points. Then to emancipate those canals which are owned or controlled by the railways, as until this is done, no scheme for any general improvement can be satisfactorily promoted by any party.

Next to this proposal must be placed purchase by the State of the whole of the canals. The question of dealing with the powerful railway monopolies must sooner or later receive attention, and unless the State offers unusual facilities to the independent canal companies or undertakes the task itself, the traders who are removed from the seaboard must either allow their trade to be taken from them by the foreigner, or, if possible, move their works to the coast. The mining industries, however, are so placed that they cannot move their works, their operations must be continued on the site where the mineral is found, and consequently they are in the hands of the carrying power for the time being within the district. Such, unfortunately, is the condition of the mining industry of South Staffordshire and East Worcestershire. The canals in South Staffordshire, which form the natural outlets of their products, have become practically the property of the competing railway, a grave mistake. No improvements have been undertaken since the railway company made itself the monopolist. The mistake, however, is capable of being, to a large extent, repaired, not by making immense waterways or ship-canals, which would never be used by ships, but by emancipation and amalgamation of the existing canals, coupled with a moderate expenditure of capital increased from time to time as the exigencies of the trade requires, and only upon these lines can this be successfully accomplished.

The following paper by Mr. W. H. Wheeler on "Birmingham and its Canal-connexions with the Seaports," was taken as read :—

BIRMINGHAM AND ITS CANAL-CONNEXIONS WITH THE SEAPORTS.

By W. H. WHEELER, M. Inst. C.E.

Birmingham might be regarded as the most central town of England. The trade and industries of the district are of a character specially adapted for carriage by water. In and around the town there exists the largest network of canals of any part of the kingdom, and over these there passed a greater number of tons per mile than on any other system. From Birmingham radiate a series of waterways, which put it in communication with the Thames, the Humber, the Severn, and the Mersey. These canals, however, practically remain in the same condition as when they were originally constructed, and very little has been done to adapt them to the altered conditions of the present day and to enable them to fulfil modern requirements.

Owing to its inland position and distance from the great ports, a system of properly-developed waterways is of the utmost importance to the maintenance and prosperity of the trade and manufactures of the district.

Canals are eminently adapted for the conveyance of the minerals in which The Federated Institution of Mining Engineers is interested, and of those products for the manufacture of which coal forms an essential factor. The Institution is therefore to be congratulated on having afforded an opportunity for eliciting information of a valuable character from the papers which have been contributed, and the writer expresses his thanks for being allowed to add some farther comments.

It was remarked at the meeting by one of the members of the Institution that the most important thing to be done in furthering the prosperity of the mining industry, and generally that of the country, was to cultivate foreign trade, and that the great drawback to this at the present time was the rates which had to be paid for transport compared with other countries.

For economical transport it is essential that any large manufacturing district should be placed in direct communication with one of the great seaports by an efficient system of waterways, both as a means of conveying manufactures and minerals for export and of conveying the food and other materials imported; and also as a means of keeping down railway rates by an independent competitive system. Any district that is not so provided can only carry on its trade at a considerable disadvantage, as compared with those equipped with this advantage. Leeds, Manchester, and Sheffield have all realized this fact; the former by improving existing waterways and assimilating as far as possible the methods of conducting its transport-service to that of the railways; Manchester by making the city itself a seaport; and Sheffield by freeing its waterways from the domination of the railway interest, and by obtaining powers to adapt them to modern requirements, and to allow of the passage of moderate-sized sea-going steamers up to the heart of the town.

Birmingham, to whom, from the nature of its trade, efficient water-communication is even of more importance than to any of these towns, does not yet appear to have realized this fact, and remains, so far as water-transport is concerned, in the same condition as before the advent of railways. Notwithstanding the convincing fact of the value of canals, as evidenced by the large traffic carried on along the waterways in the immediate neighbourhood, practically nothing has been done to bring these up to modern requirements. Small locks, shallow water, and horse-haulage of boats of small tonnage still reign as in former days. The companies which control the several systems round Birmingham have taken no steps to provide steam-haulage, or to act themselves as carriers, or even to adopt the conveniences afforded by railway transport. The whole traffic is left to the slumbering energy of the bye-trader and barge-owner. All attempts to open up an improved waterway to the seaports have hitherto failed, and the advantages to be derived from economical transport by water still lie dormant.

The full value of a waterway cannot be realized so long as old ways and antiquated customs are maintained, nor until the service conforms to modern ideas and requirements. Since the advent of railways, the functions of canals have changed, and all attempts to maintain them with commercial success on the old footing must fail.

During the last few years, considerable attention has been directed to the subject of canals and water-transport, and a very great number of papers and pamphlets have been written on the subject. The essence of these consists in a lament that a portion of the canal-system has fallen into the hands of the railway companies; and in a comparison between our canal-system and that of France and Belgium. As regards the former, where the necessity arises the remedy can be secured, as in the case of the transfer of the canals belonging to the Manchester, Sheffield, and Lincolnshire Railway Company to an independent management. As regards the second, the analogy does not hold good. The circumstances of this country and those of France and Belgium are entirely different. In the latter the waterways are owned by the State, and the works of improvement are carried out by the Government. In England, every work of the kind is carried out by private enterprize, and must have a reasonable chance of commercial success to be taken up. Again, England is a sea-girt nation, with no less than eight first-class ports in a coast-line of 1,820 miles. Communication between these by coasting steamers is therefore easy, and can be accomplished in much less time and at less cost than by canal. There is no large manufacturing town in England that is more than about 80 miles in a direct line from a first-class seaport; and taking the country south of the Firth of Forth there is only 42½ square miles to each mile of coast. France has only two first-class ports, one in the north and the other in the extreme south, over a coast-line of 1,360 miles. Its capital city is 100 miles from the nearest seaport, and the towns in the centre of the country are from 250 to 300 miles from either Havre or Marseilles. For every mile of coast-line there is 162 square miles of country behind it. Belgium has one large seaport and only 50 miles of coast-line, with 227 square miles of country to every mile. Germany has only two first class sea-ports, both situated on its northern coast; Frankfort and Berlin are distant from these about 250 miles, and for every mile of coast-line there are 231 square miles of country. The necessity of an extended system of inland water-communication for the distribution of produce and materials is therefore of far more importance in these countries than in England.

The numerous opportunities which the writer has had of considering this subject has convinced him that the main service to be rendered by canals in this country is by affording communication, between large inland towns and the seaports, for the conveyance of heavy produce where quick delivery is not essential; and that it is only on such lines that it will pay commercially to expend capital in enlarging and improving the existing canals. For such a service the waterway requires to be sufficiently large to allow of the passage of steamers carrying goods in boats of sufficient size, and moved at a speed adequate for a reduction of the working expenses to a minimum, and of such a character as to be able to navigate along the coast or across the Channel to the Continent. Such a waterway would be provided if the dimensions of the Aire and Calder system were adopted, namely, locks 215 feet long, 22 feet wide, and 9 feet depth of water.

A waterway capable of navigation by coasting-steamers has already been provided from the Severn to Worcester, as described in Mr. Marten's paper, and there now only remains the 30 miles of canal from Worcester to be improved to complete the system to Birmingham.

In the competition which prevails between Great Britain and other countries in the carrying trade of the world, the size of ocean-going vessels is continually being increased, and it is not an unusual occurrence for cargo-steamers trading between this country and the more distant colonies to carry 10,000 tons of cargo in one bottom. The draught required for vessels of this size makes only ports of the first-class available for them. The tendency is therefore for the import and export trade of the country to concentrate at these large seaports, and for cargoes to be distributed to the smaller seaports by coasting-steamers. This practice already prevails to a considerable extent, and an inland town that has a waterway of sufficient capacity to allow of the passage of one of these small coasting-steamers, carrying from 100 to 300 tons, has all that is required.

With the exception of certain localities, where there is a large local trade of a nature suitable for water-transport, it is only the canals connecting large towns and seaports that it would pay to bring up to a first-class standard. The second-class canals may be made to serve an useful purpose and pay a moderate dividend to the owners as feeders and distributors, and by performing those functions in agricultural districts which it is now sought to provide by light railways. For these purposes boats carrying small cargoes at small speeds are sufficient. Without any great structural alterations, such canals if adapted to the modern system of transport and the service more nearly assimilated to that of the railways, might be made to serve a very useful purpose, not only as an economical means of conveyance, but as keeping prices within moderate limits on the railways.

Mr. Wells, in his paper, calls attention to the deplorable condition of the canal-system between the Thames and the Severn, and intimates that this is one of the main systems that should be developed into a first-class canal. From this opinion the writer differs. The necessity for water-communication between the Thames and the Severn is admitted, but this can be accomplished in less time and at half the cost by small coasting-steamers than by the canal system, even if improved. The distance round the coast may be considerably longer, but less power would be expended in driving a boat in open water than in hauling the same load in several small barges through a shallow and narrow waterway, and in raising and lowering it nearly 500 feet above sea-level through 165 locks.

Birmingham is situated about an equal distance from the Thames and Humber seaports on the east side, and about half that distance from the Mersey and the Severn on the west. The main difficulty to be overcome is the ascent and descent of between 400 and 500 feet above sea-level. With modern appliances this forms no serious objection. The question of the most advantageous seaport with which to connect is lucidly set forth in the paper by Mr. Vernon-Harcourt. The writer agrees with Mr. Vernon-Harcourt and Mr. Marten that the plan laid out by Mr. Keeling offers the greatest advantages, and that the Severn is the natural seaport for Birmingham. The length of canal from Birmingham to Worcester that would require improvement is only 30 miles, and the cost by this route is considerably less than that of any other scheme that has been proposed. It is useless to attempt any scheme that will not offer a reasonable prospect of being commercially successful, and the expenditure of £600,000 for this outlet seems much more likely to give a return than the £5,000,000 estimated for the Weaver route.

A canal-system, affording accommodation to steamboats of 300 tons and capable of coast-navigation, would at once give to Birmingham sea-communication with Bristol, Cardiff, Swansea, and the other Severn seaports, and also with Liverpool, the Thames, and with Rouen, Antwerp, Paris, and all the Continental seaports.

Considering the immense advantage which such a scheme is likely to confer on Birmingham by giving it an outlet to the sea, and on Cardiff by affording facilities for the import trade which it so much desires, it is a matter of surprise that communication with the sea by a canal of adequate dimensions has been so long deferred.

Mr. J. A. Saner (Northwich) wrote that he agreed with Mr. Marten's remarks upon the necessity for the removal of overhead bridges of such low headway as that at Westgate near Gloucester, on all navigations which are to be navigated by steamers, even if their masts are made to lower. On the other hand, his (Mr. Saner's) paper would support Mr. Marten in his proposal to build special vessels for navigating the Severn with the bridge as it was. His experience on the Weaver fully corroborates Mr. Vernon-Harcourt's view of the rapidity with which locks can be worked with cylindrical sluices; these have, however, the disadvantage that they do not clear the detritus and mud away from the bottom of the lock, and so it is left to accumulate in the gate-recesses; this obstacle, however, is easily overcome by providing small sluice-paddles at the side or in the lower portion of the gates. He strongly supported Mr. Vernon-Harcourt's view as to the possibility of using hydraulic canal-lifts on an extensive scale. He had had charge of the Anderton lift for the past eight years, but he had also visited the French lifts, and he might repeat here what he had intimated in his paper, that during the severe frost he had kept the Anderton lift working until the Trent and Mersey canal was absolutely stopped for traffic. With his farther experience of severe weather, he was still assured of the possibility of working such lifts in the English climate, provided due precautions were taken to have the pipes and valves properly protected. Although the engineering difficulties to be overcome in the route from Birmingham to the Mersey *via* the river Weaver are no doubt greater than those which will be met with in connecting the same city *via* Worcester with the river Severn (and he had travelled over both routes), he could not but think that the very much more densely-populated country, including the Potteries of Staffordshire, through which the Mersey canal would pass, would be greatly in favour of that route. Not only because there would be direct connexion by water between the three large centres of industry, but the existing works of the Weaver and the Manchester ship-canal, etc., would amply accommodate the increased traffic for many years. His own view of the case was, that from the Midland counties there was not only room for the Birmingham to Liverpool canal *via* the Weaver, but also for the Birmingham to Bristol canal *via* the river Severn.

Mr. Geo. W. Keeling (Cheltenham) wrote that Mr. Vernon-Harcourt in his interesting paper had so very clearly stated the facts, and he was generally so much in accord with the views which that gentleman had expressed that he had but few remarks to offer. The result of some years' experience of the available water-supply to the Worcester and Birmingham canal had led him to the conclusion that it would not be more than sufficient to be relied upon in all seasons to supply and work the traffic on a canal of the proposed dimensions—of 66 feet in width and 9 feet in depth—large enough to navigate vessels carrying 200 tons (or lighters carrying 250 tons). This size would be convenient for the use of coasting-steamers carrying Birmingham goods to the Bristol Channel and other ports. No doubt a 400 tons vessel would be better for imported grain and timber, but the supply of water would be a serious difficulty for a canal large enough to accommodate such vessels, and the cost of the works would be largely increased. The configuration of the ground between Tardebigge and Stoke Prior was more favourable for an inclined lift than for a series of vertical lifts, and for this and other reasons he thought that an inclined lift on this rise of 250 feet would be the most economical in cost of construction and in working; but it was not unlikely that the chain of six locks at Dodderhill, and other sets of six locks might be advantageously replaced by a hydraulic lift. An advantage of the Droitwich route, compared with Worcester, was that it would avoid costly works on the portion of the canal passing through the city of Worcester, and, moreover, would make use of the water-supply from the river Salwarpe. The canal between Sharpness and Gloucester was a ship-canal, and Gloucester, by water, was within 60 miles of Birmingham. The river Severn (Gloucester to Worcester, 30 miles) was navigable for vessels carrying at least 200 tons, and it was anticipated would be available for vessels of nearly 350 tons. The Worcester and Birmingham canal (29 miles in length) is an independent waterway. The estimated cost of the improvements was as stated about £600,000, or, together with the acquisition of the canal, say £800,000. The estimated increase of traffic, in order to pay 5 per cent., was 800,000 tons only, and the cost of transit between Sharpness docks and Birmingham was 3s. 6d. per ton on heavy goods. The acquisition of any property other than the Worcester and Birmingham canal was not necessary, for 200 tons vessels could, as already mentioned, reach Worcester, and by means of the improved canal, would furnish access between Birmingham and the seaports in the Bristol Channel or on the coast, Liverpool, Ireland, etc. It cannot therefore be described as a costly scheme, but by its means the desired relief in cheaper transit could be obtained at the least possible expenditure. The Bristol Channel imports to the Midlands exceed those of either London or Liverpool. They consist chiefly of grain and timber, for which it is more important to secure cheap transit than for miscellaneous manufactured goods of light weight for export.

Mr. **Lyonel Clark** (London) wrote that he had been engaged as assistant to his uncle, the late Mr. Edwin Clark, in the survey of the route for the proposed canal of large section from Birmingham to Liverpool, referred to in Mr. Vernon-Harcourt's paper. This canal was surveyed by Sir James Brunlees, who acted as the engineer, Mr. Clark's share in the undertaking being the designing of the hydraulic lifts similar to those which he had designed for the French and Belgian governments. As he (Mr. L. Clark) had been the resident engineer in charge of these lifts he was naturally asked to look over the route of the Birmingham and Liverpool canal with a view to the best placement of the necessary lifts. He might say that no difficulties were met with, but of course care had to be taken (similar to that necessary in the case of the Belgian lifts, situated in the Centre coal-field), that sites were not selected in the vicinity of mines which might endanger the stability of the lifts. This danger, however, only existed in the section between Birmingham and Wolverhampton, it was not a serious difficulty, and generally speaking the route adopted was perfectly feasible. The lifts on the proposed canal were designed to take vessels 100 feet long by 22 feet beam and drawing 9½ to 10 feet of water, with a carrying capacity of 380 to 400 tons. The lifts were double, that is, one trough served the up and the other the down traffic. With the past experience of the Belgian and French lifts to guide them, these machines were naturally considerably simplified, and consequently the cost reduced so much that the estimate for an average 50 feet double lift for boats of the type above-mentioned did not exceed £30,000. This figure shows a considerable reduction on the cost of the Belgian lifts, but then it must be remembered that the latter were the first of the kind constructed, and were built for the Government without regard to economy. This economy, however, was not gained at the cost of efficiency, and, indeed, in one or two points they would be an improvement on the Belgian lifts. The most important question, however, in the design of these lifts was that of the size of the boat. This point was a very important one, and required considerable thought. It was evident that so important a canal, with its numerous branch waterways, would require a class of vessel to be built specially for use thereon, and on all the new canals which would be sure to adopt the same type. In other words, these boats would form a type for a large portion of the canals of England. The boats navigating the French and Belgian canals and the larger type that are to be found on the Meuse and the Rhine and other great Continental rivers are well known. On English canals, however, with the exception of the Weaver navigation, it may be said that there are no boats of any large size, for "monkey barges" and even "dukers" can never carry enough cargo to make a canal a paying investment. The French and Belgian boats, whilst of the right capacity, were considered to be rather too long for handy navigation, and as they would have to cross the estuary of the Mersey they would undoubtedly be too weak. It was decided, therefore, in consultation with Sir J. Brunlees, to take a shorter and stouter vessel as a type. Eventually the length was settled at 100 feet, and in order to get the necessary carrying capacity the draught was increased to 10 feet, as it appeared better in every way to expand in the direction of draught rather than beam. Passing through valuable land, and indeed over a portion of the route, following and widening existing canals, it was evidently an advantage to take as little surface as possible whilst the water-supply, a serious difficulty over a portion of the route, would be improved by the lesser area exposed to evaporation. The advantage of extra depth also affected the boats themselves as it would certainly enable them, for short voyages at least, to take the sea, and so place Birmingham in direct communication with many of the smaller ports. Lastly, lifts of these dimensions would accommodate the existing boats employed on the Weaver navigation. He would not like to say that such a type of boat would be the best in all cases; indeed in some countries it would not be. For instance, the writer's firm had lately been in correspondence with the Government engineer with regard to lifts on the Trent Valley canal in Canada, to accommodate vessels of a length of 134 feet, a beam of 33 feet, and a draught of 6 feet. In a country like Canada, where land is not yet high-priced, such a section may be the best, but he did not think that this would be the case with the Birmingham canal. At any rate the question was an extremely interesting one, and if canals were to come into favour again in England, as he firmly believed they would, it was one that would have to be settled. He would like to see The Federated Institution of Mining Engineers leading the way in this direction and settling on a type of boat, keeping in view the adoption of lifts, which from their cheapness, rapidity of working, and great saving of water, must in some cases at least be reckoned on, so that a future canal-expansion may not be hindered hereafter by a fresh "battle of the gauges." Mr. Vernon-Harcourt in his present paper favoured the Gloucester route on the score of smaller expense and greater facility. On these grounds there could be no doubt that it was the best, but one could hardly imagine that a city of the importance of Birmingham would seek only the cheapest method. What it would probably ask was, which was the best? The answer to that question could only be—the Liverpool route. There were no industrial districts lying south of Birmingham, and even when the river Severn was reached there was no shipping port of great importance until Cardiff, Swansea, or Bristol were met with in the Bristol Channel. These ports, it must also be remembered, are not what one would call general ports, but rather special in their shipments, dealing indeed very much in the same class of exports as Birmingham, and being moreover manufacturing centres for a similar type of work. The river Severn is therefore merely a port for Birmingham exports, with no return freights, and besides offers no great development of traffic along the route. By the Liverpool route, on the contrary, the canal would pass through the most productive portions of England. Beginning with Wolverhampton, it would pass through Stafford and the Black Country with its exports of heavy goods; it would pass through the salt districts; it would join the Weaver, the most successful navigation in England, and by this river it would connect both to Manchester and Liverpool. All these districts produce heavy imperishable goods of precisely the class which seeks canal transit. At the end of the canal, there would be the port of Liverpool, a general place of consignment and not a competing manufacturing centre, whilst Manchester could exchange her heavy stuffs for Birmingham's machinery. With these facts before the members, it could not be doubted that, although the capital required might be larger, this route would give a better paying return than the shorter and less expensive one to Gloucester. It had been advanced against the Liverpool route that it would have to contend with the opposition of the railway companies, and also that existing canals would have to be purchased. The latter condition, he ventured to think, would not be a disadvantage. In the inspection of the route, Sir J. Brunlees and Mr. E. Clark went carefully into this matter, and came to the conclusion that there would be no practical difficulty in enlarging the existing canals without interrupting the traffic beyond a day or two at a time. If this plan were adopted, the effect would be that the new company would, from the very first, be earning money, and be in a position to pay a small dividend to its shareholders. It was difficult to say what the opposition of the railways would be, but railway directors were, as a rule, men of sense and knowledge; and with the fact, which must now begin to stare them in the face, that the existing lines were hardly sufficient to cope with the ever-increasing passenger and goods traffic, it was quite possible that they might ask themselves whether, instead of doubling or trebling the railways at an enormous expense, it would not be wiser, certainly not to oppose, and possibly to assist, a means of transport that would relieve them of the class of goods that are most suitably conveyed by water-carriage, and confine their energies to coping with the passenger traffic which will certainly spring up along the route of a canal as fast as the canal itself carries goods. In France and Belgium, the State, the owner of every means of intercommunication, was constructing canals and railways side by side, and allowing each to take the traffic that suited it best. It would be optimistic to hope that we should ever arrive at that consummation, but he (Mr. L. Clarke) believed that if one successful canal were started, there would be a great future development in this direction. It appeared to him that a communication between Liverpool, the largest seaport, and Manchester and Birmingham, the two largest manufacturing centres in England, was a scheme that promised the greatest measure of success. In conclusion, he might say that although he considered the Liverpool route the best, he would not say a word against the Gloucester scheme, which was one that he thought would certainly soon follow the formation of the Liverpool route, as it was a simple, short, and convenient route, and by replacing the locks where practicable with lifts so as to save time and water (a consideration at the Birmingham end), it could undoubtedly be very cheaply constructed. Nevertheless, in his mind it could not compare with the Liverpool route, which was the only practical solution of the problem of connecting Birmingham with the sea.

Mr. SAMUEL LLOYD (Birmingham) said that in 1882 a motion was made in the House of Commons for the appointment of a committee, which awakened in Birmingham and indeed all through the country a very considerable interest in canals. The commission issued a lengthy report full of useful matter. The Council of Birmingham appointed a committee to examine into the different canal-routes between Birmingham and the sea. The committee had to report in which direction the greatest quantity of goods were sent from the centre of England to the coast. They found that of the goods Birmingham and neighbourhood exported 40 per cent., and 19 per cent. of the imports were received *via* London; and *via* Liverpool, 43 per cent. of the exports and 24 of the imports. The Severn ports were most admirable, but the traffic would not go in that direction. They only exported through the Severn ports 3 per cent. and received 25 per cent. In South Wales, exports 3, imports 8; other ports, exports 1, imports 7. If they only had a Liverpool with its miles of docks at Sharpness the whole question would be solved, as the money would be subscribed in a month to improve the canal, but the difficulty was that Sharpness was not a port. If they could only get the goods to Liverpool or London, the ships would there take them to every part of the world.

Mr. BERIAH SHEPHERD (Edgbaston) said that the line for a canal from Birmingham to the Mersey was proposed by himself previous to 1890, and at his suggestion Sir James Brunlees and Mr. McKerrow were instructed to make the survey. Mr. Harcourt said that "the scheme would undoubtedly provide a waterway for Birmingham to the sea, quite on a level with the largest inland canals on the Continent; and the proposed system of lifts would enable the great changes of level to be rapidly accomplished with a small expenditure of water. This canal, however, would be a very costly work, being estimated by its promoters at £5,000,000." Whatever may be the advantage of the proposed route for a canal to the Severn, by reason of its shorter distance and consequent smaller cost, he believed that he would have little difficulty in showing that the importance of the districts to be served by the canal to the Weaver far outweigh any considerations of the cost of construction, which by no means assumed the large proportions indicated by Mr. Harcourt. It is proposed to construct the Birmingham and Liverpool ship-canal (which, as will be seen, is not intended for vessels of more than 400 tons) in three sections: (1) From the Weaver to Stoke-upon-Trent; (2) from Stoke-upon-Trent to Wolverhampton; and (3) from Wolverhampton to Birmingham (if required). The cost of No. 1 and 2 sections, viz., from the Weaver to Wolverhampton, as estimated by Sir J. Brunlees and Messrs. McKerrow and Clark, was £2,167,450, exclusive of land, of which about 800 acres would be required: some 7 miles would pass through the Duke of Sutherland's estate. The late Duke of Sutherland expressed himself most favourably as to the importance of water-communication to the industries of the Potteries districts, and said that he would render every assistance, and accept paid-up shares for the value of the land required for the undertaking. He (Mr. Shepherd) estimated that 800 acres of land, and compensation for disturbance, etc., would cost £150,000, and adding the estimated cost of the canal to Wolverhampton, £2,167,450, the total cost would be £2,317,450, or about half the amount mentioned by Mr. Harcourt. The sides of the proposed canal are to be concreted to a depth of 6 feet below water-line. This lining would allow boats to run at almost any speed, as the displacement of water would not affect the embankments, and further, it would provide wharfage along the whole length of the canal. The hydraulic lifts would change the levels at the rate of 20 feet per minute: the variation in level between the Weaver and Wolverhampton was 746 feet, and in his opinion the journey from Wolverhampton to Liverpool would easily be accomplished within fourteen hours. He might also mention another section which was under contemplation, viz., the improvement of the Trent and Mersey canal from Stone to Burton-upon-Trent. He might also direct attention to the great importance for traffic of the districts through which this canal would pass; probably there was not another canal-route that would give anything approaching the amount of traffic that could be sent by this canal to the Weaver. Wolverhampton, South and North Staffordshire, with its coal, iron, and pottery industries, would contribute a constant and a largely increasing traffic, ensuring a large and permanent source of revenue. Shut out of sea-communication at a cheap rate as those districts now are, he considered that unless some such facilities were afforded, such as a really efficient waterway to the sea, the heavy-iron trade of those districts was doomed to extinction at no distant date. The cost of conveyance from Wolverhampton to Liverpool would not exceed 6d. per ton, and this sum would pay interest at the rate of 10 per cent. on barge and steamer, and also cover the working-charges.

A Member suggested that the Worcester canal, and a mile or two of docks at Sharpness, specially to accommodate Birmingham traffic, could be together made at less cost and trouble than the proposed canal to the Weaver. It was a mistake to put all one's eggs in one basket, and for many reasons it was a mistake to throw so much traffic into the single estuary of the Mersey. Moreover, the future tendency of American trade was to move from the Mersey towards Southampton and the Bristol Channel ports.

Mr. E. D. Marten wrote, with respect to the various schemes of improved canal communication between Birmingham and the sea-board, that, in his opinion, Mr. W. H. Wheeler had put the case in a nutshell when he said that "It is useless to attempt any scheme that will not offer a reasonable prospect of being commercially successful," and he suggested to the promoters of the Liverpool scheme whether a canal of much smaller dimensions than what was proposed, but yet of sufficient size for the economical use of steam-haulage, would not be more likely to command the confidence of the investing public than the larger canal they favoured, whilst offering practically the same advantages with regard to cheap transport of goods. In the year 1886, the writer's late father reported to a body of Midland traders as to the improvement of the canal-system between London and Birmingham, and he then arrived at the conclusion that the best form of improved canal was one having a top-width of 45 feet, a bottom-width of 21 feet, a navigable depth of 8 feet, and with locks 160 feet long by 14½ feet wide, with 7 feet of water on the sills. Such a canal was well adapted to the use of steam-haulage, and the size of the locks was such as would admit of the passage through them of trains of steam-tugged canal boats, or of single steam vessels carrying 140 tons of cargo. The canals thus reported upon were all free from railway control. A detailed survey, lasting many weeks, and costing a large sum of money, was made by the writer and Mr. Gordon Thomas of the Grand Junction canal. It was found, as the result of this survey, that the very moderate improvements contemplated would cost (exclusive of the purchase of the canals themselves) about £1,250,000, the distance being 132 miles. The *pro rata* cost of similarly improving the existing 65 miles of canal between Birmingham and Liverpool, *via* the Weaver navigation, would probably be somewhat heavier, owing to the great difficulties which would be met with through the mining district between Birmingham and Wolverhampton, and the cost of a new connecting canal at the Weaver end; but it would not be likely to exceed £850,000. The promoters' estimate for a new Liverpool ship-canal, stopping short at Wolverhampton, was £2,317,450, whilst the estimated cost of carrying it on to Birmingham (the only means by which it could have the smallest prospect of success) appeared to be too large for publication. The existing 65 miles of canals, for the most part, were undoubtedly railway-owned, but in view of the Sheffield and South Yorkshire precedent, this should present no great difficulty. The advantage of the proposed new ship-canal, as compared with the suggested improvement of the existing canals, would be (if carried into Birmingham) that goods would of course be conveyed more cheaply to the ocean liners at Liverpool in one bottom of 400 tons rather than in bottoms of 140 tons only, and farther, that goods intended for coastwise destinations, or for the Continent, would be put on board at Birmingham and carried without transhipment to the port for which they were intended. These advantages, however, would probably be outweighed by the enormous burden of capital which the new ship-canal would have to sustain, as compared with the moderate outlay required for the suggested improvement of the existing canals. It must also be borne in mind that the purchase money to be paid for the existing canals in their present state would be determined almost entirely by their net revenue, which would become a valuable asset in the hands of the purchasing company, and that a company constructing a new canal would start without any such advantage. With the Severn route the case for a small ship-canal was entirely different. There already existed a waterway for sea-going steamers of 300 tons burthen up to Worcester, within 30 miles of Birmingham, and thence to the latter city there was a canal entirely free from railway control. This canal, Mr. G. W. Keeling, the chief engineer to the navigation of which it formed a section, estimated could be made navigable for barges of 200 to 250 tons burthen for £600,000, and on the dimensions which form the basis of his estimate, it was clear that for a comparatively small farther outlay the sea-going steamers of 300 tons burden which already could come to Worcester might be accommodated on the canal, up to Birmingham. The extra expense of so doing would be well repaid by the great gain resulting from the expenditure, whereby sea-going steamers of 300 tons burthen might be loaded in Birmingham and deliver their cargoes coastwise or at Continental seaports. The writer was aware that many traders preferred London or Liverpool as ports of export, instead of the Severn ports. He considered, however, that there was sufficient traffic to support improvement in all these directions. Those traders who would gain by the establishment of a line of sea-going steamers between Birmingham and Continental or other over-sea ports should support the Severn scheme, which was by far the cheapest for such an object, and which would also place them in direct water-communication by steam-vessel with such considerable ports as Cardiff, Bristol, Newport, Swansea, Milford, etc. Those traders, on the contrary, who favoured the ports of London or Liverpool, would find the capital for the improvement, on the lines above indicated, of the canals between Birmingham and either or both of those places, bearing in mind, however, that the canals on the London route were free from railway control, whilst to get to Liverpool it would be necessary either to wrest the existing canals from the hands of the London and North Western Railway Company, or else to make an entirely new competing canal, a scheme for which Parliament would require to hear very strong reasons indeed before sanctioning it. Throughout his (Mr. Marten's) remarks the writer had, for convenience, used the expression "steam-haulage." He was of opinion, however, that the best form of motor will eventually be found to be either oil or compressed gas, as an oil or gas engine and its fuel takes up much less space than a steam engine and fuel, and consequently more cargo could be conveyed for the same money.

Mr. L. F. VERNON-HARCOURT, in reply, observed that he agreed with Mr. Wheeler in the view that the conditions of inland navigation were different in Great Britain to those on the Continent, owing to the great length of coast-line and the number of seaports of Great Britain in proportion to its area, as compared with most of the countries of continental Europe. Birmingham, however, was a large, flourishing inland town at a distance from the sea-coast, and possessing, with the surrounding districts, a trade in bulky goods specially suitable for conveyance by water; and therefore it appeared that Birmingham ought to be provided with an adequate waterway to a seaport, for the reduction of the rates of transport, the expansion of its trade, and to enable it to maintain its position against foreign competition. He did not think that it would be possible to obtain Government aid for the improvement of the waterways of Great Britain, as suggested by Sir E. Leader Williams, and he much doubted the expediency of attempting the improvement of the whole network of waterways; but the Government might advantageously facilitate, as far as possible, the amalgamation of the separate links of important through routes under a single trust, so that these waterways might be made uniform in dimensions, and each route placed under one management. The only route from Birmingham to the sea which had been advocated in the discussion as preferable to the Gloucester route was the route to the Weaver. This route was very naturally preferred by Mr. Saner, the engineer to the Weaver navigation, for its adoption would greatly augment the traffic on the Weaver, and also by Mr. Lyonel Clark, who had been concerned in the preparation of the scheme, the main feature of which was the employment of hydraulic canal-lifts on a large scale, with the construction of which he was so intimately associated. He had entered upon the consideration of the subject for the paper which he had been asked to present to the meeting without any preconceived notions, and had arrived at the conclusion that the Gloucester route was the most practicable, as, owing to the physical conditions, it was much less costly than any other; and as its formation involved negotiations with only a single canal company, its accomplishment appeared far more feasible. Irrespectively of the great obstacles in the way of arrangements with other companies along the route to the Mersey and the large capital cost of the undertaking, he should have preferred the route to Liverpool by the Weaver, both on account of the connexion thereby afforded with Manchester and Liverpool, and also owing to the districts of the Potteries being served by this route. He had not the slightest engineering objection to urge against the Weaver route, if the capital could be raised and the other obstacles overcome; but he seriously doubted the possibility, under present circumstances, of obtaining the large capital required; and he was also uncertain whether the traffic could be thoroughly relied upon to secure an adequate return, even assuming that in such a large sum the estimated cost was not exceeded. Mr. Shepherd, indeed, who had stated that he was the originator of the scheme, had given a considerably lower estimate, but only for a canal between Wolverhampton and the Weaver, which was only a portion of the scheme, and would not satisfy Birmingham; whilst he had not brought forward any reasons for modifying the estimate prepared by Sir James Brunlees and Mr. McKerrow, which was published with the details of their scheme. As an engineer and a man of business, in spite of the engineering attractions of the Weaver route, he had felt bound to give the preference to a waterway which could secure Birmingham access to the sea at a moderate cost, fully within the amount which Birmingham might raise without the aid of financiers, and which afforded a good prospect of an adequate return on the capital expended. Mr. Lloyd had stated that the traffic with Birmingham passed mainly through Liverpool and London, and it was quite possible that the energy of the London and North Western Railway Company, who controlled the Birmingham canals, had directed the bulk of the traffic of the district on to their lines. The Worcester and Birmingham canal, however, even in its present condition, had a larger traffic than the waterway between Birmingham and London ; and the route by Gloucester was the shortest and easiest outlet by water for the export and import trade of the Birmingham district with foreign seaports. The vessels navigating the inland waterway could tranship their cargoes at any of the Bristol Channel seaports; and communication with every part of the world was quite as easy from Bristol, Newport, Cardiff, Barry, and Swansea, as from Liverpool or London. The great object was to obtain for Birmingham an adequate waterway to the sea at a reasonable cost, and thus, besides improving its facilities for commerce, relieve it from its dependence on railways, and place it in a more favourable position for competing successfully with foreign manufacturers. It was a somewhat utopian vision to imagine Birmingham connected by ample inland waterways with London, Liverpool, and the Bristol Channel ports, when Birmingham had hitherto failed to obtain any improvement in its antiquated waterways, and when none of the various proposals for a first-class waterway to the sea had ever passed beyond the region of speculation. Under these circumstances, it was evident that the best prospect of a solution of the difficulty lay in the selection of the least costly and most feasible of the schemes. The enlargement of the Worcester and Birmingcanal unquestionably complied with these requirements, and would place Birmingham in direct communication by water with the Bristol Channel ports; and these flourishing ports, with deep entrance channels and unimpeded access to the sea, would place Birmingham in easy connexion with every port of the world.

Mr. J. Head (London) said that he had great pleasure in proposing that the best thanks of the Institution be given to Messrs. Marten, Vernon-Harcourt, and other gentlemen for the able and instructive papers which they had communicated to the members.

Mr. Emerson Bainbridge (Sheffield) seconded the motion.

The resolution was carried.

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

SUBJECTS FOR PAPERS.

The Council of The Federated Institution of Mining Engineers invite original communications on the subjects in the following list, together with other questions of interest to mining and metallurgical engineers.

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Aerial ropeways.
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Blowing out of coal and minerals *in situ.*
Boiler explosions.
Bore-holes and prospecting.
Boring against water and gases.
Canals, inland navigation, and the canalization of rivers.
Coal-getting by machinery.
Coke manufacture.
Colliery explosions.
Colliery leases, and limited liability companies.
Compressed air as a motive-power.
Consumption of steam and water in engines.
Descriptions of coal-fields.
Diamond-mining.
Distillation of oil-shales.
Drift and placer-mining.
Duration of coal-fields of the world.
Electric mining lamps.
Electricity and its applications in mines.
Electro-metallurgy of copper.
Engine-counters and speed-recorders.
Explosions in mines.
Explosives used in mines.
Faults and veins.
Fuels and fluxes.
Gases met with in mines.
Gas producers, and gaseous fuel and illuminants.
Gas, oil, and petroleum engines.
Geology and mineralogy.
Haulage in mines.
Industrial assurance.
Inspection of mines.
Laws of mining and other concessions.
Lead-smelting.
Maintenance of canals in mining districts.
Manufacture of fuel-briquettes.
Mechanical preparation of ores and minerals.
Mechanical ventilation of mines, and efficiency of the various classes of ventilators.
Metallurgy of gold, silver, iron, copper, lead, etc.
Mineral resources of colonies.
Mining and uses of asbestos, bauxite, etc.
Occurrence of mineral ores, etc.
Ore-sampling machines.
Petroleum-deposits.
Prevention of over-winding.
Pumping machinery.
Pyrometers and their application.
Quarries and methods of quarrying.
Rectification of mineral oils.
Salt-mining, etc.
Screening, sorting, and cleaning of coal.
Shipping and discharge of coal-cargoes.
Smelting.
Spontaneous ignition of coal and coal-seams.
Submarine coal-mining.
Sulphur-mining.
Surface-arrangements of mines.
Surveying.
Tin-mining.
Tunnelling, methods and appliances.
Utilization of dust and refuse coal.
Utilization of sulphureous gases resulting from metallurgical processes.
Ventilation of coal-cargoes.
Ventilation of mines.
Water as a motive-power in mines.
Watering coal-dust.
Water-incrustations in boilers, pumps etc.
Winding arrangements at mines.
Winning and working of mines at great depths.

MEDALS AND OTHER AWARDS.

Session 1889-90.

"The Economical Working of Steam Boilers at Collieries." By Messrs. William Armstrong, Junior, and W. J. Bird.
"Improved Coal-screening and Cleaning." By Messrs. T. E. Forster and H. Ayton.
"Winding, Banking-out, and Screening Plant at East Hetton Colliery." By Mr. Simon Tate.
"Coal-getting by Machinery." By Mr. G. Blake Walker.

Session 1890-91.

"Experiments on Explosives used in Mines." By Mr. M. Walton Brown.
"Experiments with Carbonite." By Messrs. M. Walton Brown and William Foggin.
"Notes on the Coal-fields of New South Wales." By Mr. G. Blake Walker.

Session 1891-92.

President's Prize (Mr. George Lewis).

Mining in New Zealand." By Mr. G. J. Binns.

Institution Prizes.

"Observations on Petroleum in Eastern Europe, and the Method of Drilling for it." By Mr. A. W. Eastlake.

"A General Description of the South Staffordshire Coal-field, South of the Bentley Fault, and the Methods of Working the Ten Yard or Thick Coal." By Messrs. W. F. Clark and H. W. Hughes.

"An Enquiry into the Cause of the Two Seaham Explosions, 1871 and 1880, and the Pochin Explosion, 1884." By Mr. T. H. M. Stratton.

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Session 1892-93.

"The Correlation of the Coal-fields of Northern France and Southern England." By Mr. Marcel Bertrand.

"The Choice of Coarse and Fine-crushing Machinery and Processes of Ore Treatment." By Mr. A. G. Charleton.

"The Geology and Coal-deposits of Natal." By Mr. R. A. S. Redmayne.

Session 1893-94.

"A Contribution to our Knowledge of Coal-dust. Parts II. and III." By Dr. P. Phillips Bedson and Mr. W. McConnell, Jun.

"The Transmission of Power by Compressed Air." By Prof. Goodman.

"The Friction of, or Resistance to, Air-currents in Mines." By Mr. D. Murgue.

"Result of an Experimental Research into Choke-damp Poisoning, with Special Reference to Oxygen as a Restorative." By Dr. W. Ernest Thomson.

STUDENTS' MEETINGS.

Arrangements are being made for a Students' Meeting in the Newcastle-upon-Tyne district on August 13th, 14th, and 15th, 1895, limited to members under 25 years of age. A prize of the value of £5 will be awarded to the writer of the best paper on the "Prevention of Accidents in Mines." It is desirable that the length of the essays should not be less than 4,000 words or more than 8,000 words, they may be accompanied with suitable original illustrations, pertinent to the subject. All essays must be sent to the Secretary on or before June 28th, 1895.

FOREIGN ABSTRACTS.

The Secretary (Mr. Walton Brown, Neville Hall, Newcastle-upon-Tyne) will be pleased to receive communications from members who are willing to assist in the compilation of abstracts of papers upon mining, etc., appearing in foreign transactions, newspapers, etc.

INSTRUCTIONS.

All communications intended for publication by the Institution shall be clearly and legibly written in the third person, on one side of the paper only, with a wide margin on the left hand side, with proper references, and in all respects in a proper condition for being at once placed in the printer's hands.

The accompanying illustrations, if any, shall be boldly and clearly drawn on tracing cloth, uncoloured, and of suitable dimensions for insertion in the *Transactions*.

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M. Walton Brown, *Secretary*.

The Federated Institution of Mining Engineers,
Newcastle-upon-Tyne,
March 23rd, 1895.

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